Occultation Newsletter

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FROM THE PUBLISHER

This is the first issue of Volume Three. For subscription purposes, it is the third issue of 1982.

o.n.'s price is $1.40/issue, or $5.50/year (4 issues) including first class surface mailing. Back issues through *Vol. 2*, No. 13, still are priced at only $1.00/issue; later issues @ $1.40. Please see the masthead for the ordering address. Air mail shipment of *o.n.* back issues and subscriptions is 45¢/issue ($1.80/year) extra, outside the U.S.A., Canada, and Mexico.

IOTA membership, subscription included, is $11.00/year for residents of North America (including Mexico) and $16.00/year for others, to cover costs of overseas air mail. European and U. K. observers should join IOTA/ES, sending DM 20.-- to Hans-J. Bode, Bartold-Knaust Str. 8, 3000 Hannover 91, German Federal Republic.

IOTA NEWS

David W. Dunham

Preparing all of the articles for this issue took longer than expected, and this, combined with several other commitments, caused us to miss our deadline of having this distributed to you by October 31. Consequently, subscribers in the possible area of visibility of the occultation of SAO 98369 by (21) Lutetia were sent finder charts for that event separately. This issue contains finder charts for several good asteroidal occultation possibilities starting on p. 18. Some information about astrometry for these events is given on p. 4 and some general explanatory information is given with the article about 1983 events starting on p. 9. General information about these late 1982 events is given in the articles in *o.n. 2* (13), 178 and (15), 198, while world and regional maps for some of them started on p. 232 of the last issue.

While the emphasis of this issue is on asteroidal occultations, the next issue will concentrate on lunar occultations, especially those during eclipses; see p. 3. We plan to distribute it about a month after this issue, to be in time for the total lunar eclipse of December 30th, which could be especially favorable for occultations. That issue also will contain a preliminary report on occultations observed during the July 6th eclipse; *Sky and Telescope* mentioned occultations only briefly on p. 392 of their October issue, noting Paul Maley's record of 73 timings (25 of them reappearances) of occultations during the eclipse. As far as I know, the only published prediction that the moon might be darker in the northern half due to volcanic dust appeared on p. 214 of the last issue of *o.n.* The prediction, described to me by Richard Nolthenius, turned out to be quite an understatement! Time will not permit including sections on either new double stars or grazes in either this issue or the next one, but I do plan to cover these in the third issue of this volume, early next year.

On October 23, from $10^h 20^m$ to 25^m, an occultation of 8.7-mag. SAO 77190 by 10th-mag. Comet 1982f was visible from the U.S.A., the path passing from the southwest to the northeast. The prediction was announced by Lowell Observatory astronomers at the A.A.S.'s Division for Planetary Sciences meeting in Boulder, CO, a few days before the event. Very few comets have orbits known accurately enough for predicting occultations, but 1982f is one of them. The possibility and value of predicting occultations by comets was discussed at the I.A.U. meeting in Patras, Greece, in August, and efforts actually to predict them began at Lowell only recently. It is doubtful that anyone would be lucky enough to record an occultation by the nucleus, which probably would last less than 0.1 second. The idea is to obtain photoelectric records from locations close enough to the central line to record dips in the star's light by dust in the denser parts of the coma near the nucleus. Such records could be valuable for determining the amount and distribution of cometary dust near the nucleus, which could be valuable for spacecraft-targeting strategies. In spite of the fact that cometary angular velocities are generally considerably larger than those of asteroids, last-minute astrometry could be useful for cometary occultations, so that observers with portable photoelectric equipment could get close enough to the central line to record dust absorption of the star's light. I do not know whether any last-minute astrometry was attempted for the October 23rd event. It is not known whether visual observation of dimmings due to dust could be made, but it might be worth a try for occultations of bright stars.

Hans Bode announces the second European Symposium on Occultation Projects (ESOP II), to be held again at the University of Hannover's Geodetic Institute in the German Federal Republic, during 1983 March 19 and 20, from $9^h 30^m$ to $17^h 30^m$. "Presentations are welcome: You have the chance to participate and to demonstrate or discuss things you are specially interested in." The presentation abstract deadline is

December 31 and the registration deadline February 15. The registration fee is 10 DM, or 5 DM for students. Besides general discussions and reports of observations, topics will include occultations by minor planets; coordination for observations of the solar eclipse in Java and of the occultation by Neptune next June; and photomultiplier kits. Registration forms can be obtained from Hans-J. Bode, address in FROM THE PUBLISHER above.

In 1986, the European Space Agency plans to launch an astrometric satellite called HIPPARCOS. The spinning spacecraft will be able to measure positions between stars across the entire sky to an accuracy of nearly 0".01, and will be able to determine annual proper motions to similar accuracy during the mission. This is much better than absolute measurements from ground-based observatories, and comes close to the inherent precision of the most accurate occultation observations. HIPPARCOS data could reduce significantly the errors of the positions of stars in the Zodiac, so that dynamical and profile parameters can be derived to better accuracy from occultation data. HIPPARCOS requires complex observational planning, so ESA distributed forms for requests for proposed lists of stars to be observed, early this year, asking that they be completed and returned by October 1. At USNO, Tom Van Flandern and coworkers have prepared a magnetic tape of over 160,000 reduced timings of lunar occultations made from the 17th century to 1979; most of the recent timings were supplied by H.M.N.A.O. The tape has been used for various analyses. I scanned it, and the XZ star catalog disk file, with a computer program which produced a tape of star positions in the format required by the HIPPARCOS project. 15,542 stars were included and ranked according to their observational history, since HIPPARCOS will not be able to observe all requested stars to full precision. In the ranking, higher priority was given to stars which have been observed during grazes or photoelectrically, and also to stars observed during lunar eclipses and otherwise near the ecliptic, since they have special value for deriving profile corrections needed for the most accurate analysis of total solar eclipse timings for solar radius determination. A separate file of 474 C-catalog stars was created for the well-observed 1982 lunar eclipse field stars, including all stars reported to me so far whose occultations were timed during the January 9th and July 6th eclipses, and 278 stars brighter than mag. 10.5 in the December 30th field. The work was useful since in the proposal, I had to prepare a general discussion of the value of lunar occultation observations, which might be useful for other purposes. It will be fairly simple to modify the computer program used to scan the tape of observations to select only photoelectric observations, and print them in SAO number order. I had planned to produce such a photoelectric index several years ago, and now hope actually to do so early next year. Later, as soon as the backlog of graze observations is computerized by ILOC, it will be possible to produce a similar index for grazes. Gordon Taylor also sent to the HIPPARCOS project scientists a list of stars which have been observed during occultations by major and minor planets, or by their satellites.

EARLY PLANNING FOR THE OCCULTATION OF 1 VULPECULAE BY PALLAS ON 1983 MAY 29

David W. Dunham

An occultation of a 4th-magnitude star by one of the four largest asteroids occurs somewhere from the earth's surface only about once every 60 years. We are fortunate that such a once-in-a-lifetime event is predicted to occur in the southern U.S.A. next Memorial Day weekend. We hope to mobilize as many observers as possible in the predicted region of visibility, in order to define Pallas' outline in detail. In addition, we want as many observers as possible to monitor the star throughout North America, to make a detailed scan of the area around Pallas. This should result in confirmed timings of any secondary occultations by satellites of Pallas, especially the large one expected from speckle interferometer observations.

The usual information about the occultation is given in the tables on p. 10 and in the notes on p. 20. A world map and North American regional map for the event will be published in a future issue, but these already have been published in *O.N.* 2 (11), 154; a discussion of predictions based on various star catalogs also is given on p. 146 of that issue. Since then, astrometric observations have been made by Klemola at Lick Observatory, of the star and of Pallas last February. The Lick observations of Pallas are in good agreement with a recently improved orbit by G. Sitarski. Edward Bowell, Lowell Observatory, and I have used these data to compute the path of the occultation, and we agree that its center will be very close to the dashed curve marked "SAO(GC)" at 0".27 S on the *O.N.* 2 (11) map; hence, it goes over Bradenton, FL; Houston, TX; and northwestern Mexico. We feel that an uncertainty of a path width (0".28) remains, so the path could pass almost entirely south of the U.S.A., or could shift north, crossing Georgia, Oklahoma, and southern California. The prediction uncertainty will be reduced to a small fraction of Pallas' diameter when the two objects can be photographed on the same astrographic plates during the few weeks and days before the event.

Planning for this rare event can not begin too early. Paul Maley already has written a long article about the event suitable for *Sky and Telescope* readers, and has obtained permission to have prediction updates broadcast on WWV during the week before the occultation. Since anyone with a steadily mounted pair of binoculars will be able to observe the star, we hope to enlist the help of many others interested in science in general, not just amateur and professional astronomers, with articles in magazines such as *Scientific American*, *Science News*, and *Omni*. Since observations throughout North America are potentially useful, we should have coordinators, from whom more information can be obtained, in as many metropolitan areas as possible. Among those generally interested in science, as well as among amateur astronomers, portable tape recorders are relatively common, but WWV receivers and short-wave radios are relatively rare. Hence, I suggest that some area coordinators either record, or make arrangements to have a recording made, of WWV along with a clear-channel am standard-broadcast station which covers the region. This method of providing a readily accessible secondary time reference has been used quite successfully during some lunar grazing occultation expeditions, but needs to be done on a continental scale for the Pallas occultation. Perhaps some former members of the disbanded Asteroid Intercept Radio Net and other radio hams can be enlisted to help with this. The aim will be to publish a list of call letters, frequencies, and cities of am radio stations which will be calibrated with WWV in the popular magazines mentioned above. Those who make arrangements to record specific stations should inform me.

Prospective observers should take some care not to make conflicting plans for the Memorial Day weekend. If you visit relatives in a distant city, take some equipment with you so that you can record the star's visibility around the time of closest approach wherever you are; a mobile capability might be useful to travel some to optimize weather prospects. A total solar eclipse will occur on the other side of the world less than 2 weeks after this much rarer occultation by Pallas. Most expeditions planned for the eclipse leave North America after May 29. Two exceptions are the Bart Bok and Jim Gall tours, which *o.n.* readers are advised to avoid. A more serious conflict may be caused by amateur meetings that weekend. Since the moon will be quite bright that weekend, the 1983 Texas Starparty will not conflict, but will be held closer to new moon in June. In spite of the moon, the Riverside Telescope Makers Conference will be held at Big Bear Lake, CA, that weekend. Steve Edberg suggested that spreading out observers across southern California the evening of the occultation be made a part of the meeting agenda, but Clifford Holmes thinks this will be impractical due to the difficulty of travel to and from Big Bear. In order to observe the occultation by Pallas itself, chances are good that southern Californians will need to make a rather long trip into Baja California.

ILOC NEWS

David W. Dunham

A summary of work performed by the International Lunar Occultation Centre was distributed by them at the I.A.U. General Assembly in Patras, Greece, and is reproduced on p. 4 . Apparently, during the early part of this year, ILOC was mainly preoccupied with completing and making operational computer programs for producing tables of total occultations and maps of grazing occultations, which had to be produced for 1983 in time to meet various publication deadlines. This was accomplished successfully, so presumably now they are devoting more effort to the reduction of the observations they have received, and we are hopeful that they soon will start distributing residuals back to the observers. According to their 1982 August *Circular*, the occultation subsection of the Lunar Section of the British Astronomical Association is considering computing preliminary reductions of their members' observations themselves. In most cases, the detailed USNO total occultation predictions are accurate enough that observers can tell how they are doing, since a large fraction of observed timings should be within the listed accuracy, given in seconds, of the predicted time.

In late July, I sent Dr. Kubo at ILOC a magnetic tape containing data for five special occultation catalogs which I have used for predictions; they are listed below:

<u>USNO</u> <u>Description</u>

- C 1982 eclipses, Praesepe, Milky Way; see p. 222 of the last issue
- K Some AGK3 and Yale (non-SAO) stars not in XZ; predictions for these K stars have been included with regular USNO (mainly X) predictions during the last few years
- M 1979 September 6 lunar eclipse field
- B 1981 July 17 lunar eclipse field
- J Hyades, 1978 eclipses, Milky Way, etc.

Kubo wrote back, saying that they should be able to use the data, and that observers could include timings of occultations of these stars on the ILOC total occultation report forms, using the letters above (which are the prefixes of the USNO reference numbers given in the predictions; ILOC did not previously use these letters) in the catalog code column 16. Consequently, from now on (starting with all 1982 timings), all timings of these stars should be reported to ILOC rather than to me. Only for occultations timed during lunar eclipses should a copy of the report also be sent to David Herald or to me. As stated on p. 223 of the last issue, when available, ZC (ILOC catalog code R; blank prefix for USNO ref. no. on regular USNO predictions), SAO, or X numbers should be given in column 16 of the ILOC forms, in that order of preference. Otherwise, use K, C, or J, and the associated USNO ref. number, obtained from the main list, remembering that C or J may be incorrectly reversed in the chronologically ordered lists following the main lists (in star number order) of the extended USNO predictions. Do not report the A.C. numbers prefixed with A or B in the DM number column of the extended USNO predictions.

Roy Bishop, editor of the R.A.S.C. *Observer's Handbook 1983*, has sent me the ILOC computer-produced lists and maps for total occultations and grazes in North America, for preparing my 1983 Occultation Highlights article for *Sky and Telescope*. At my suggestion, some new standard stations have been added, and a few others moved to coincide with large cities, to give better prediction coverage for most North Americans. However, due to space limitations in the *Observer's Handbook*, the total occultation lists include only stars and planets of mag. 6.0 or brighter. More extensive total occultation predictions are available from Walter Morgan, as noted in my Occultation Highlights articles in *Sky and Telescope*, or from the USNO for active observers. The graze maps and lists include Z.C. stars to mag. 7.5, so that their coverage is very similar to that of the graze maps produced by H.M.N.A.O. for recent years.

PREDICTIONS OF OCCULTATIONS DURING THE DECEMBER 30TH TOTAL LUNAR ECLIPSE

David W. Dunham

Detailed U.S. Naval Observatory (USNO) predictions of total occultations were computed for both the July 6th and December 30th total lunar eclipse and distributed to all IOTA members who had reported accurate coordinates to either USNO or to IOTA; see p. 214 and 222 of the last issue. IOTA members should also now have detailed predictions of grazes of Z.C., SAO, and AGK3 stars which occur during the December 30th eclipse within their specified travel distances.

If you need further predictions of occultations or grazes during the December 30th eclipse, request them from me at P.O. Box 7488, Silver Spring, MD 20907, U.S.A., as soon as possible. It might not be possible to compute and send you predictions in time if your request is received after December 10, due to my holiday travel plans and/or slow mail delivery, especially to overseas locations, during the holidays. A payment will be asked for detailed predictions in an article about the eclipse occultations in the December issue of *Sky and Telescope*, but these predictions are free for IOTA members. You should request predictions if you were not an IOTA member in June, or if you need predictions for another location, perhaps one you will be visiting during the holidays, or for a site in a predicted graze path more than a few miles from your regular prediction station. Be sure to specify coordinates accurately enough, including height above sea level. An accuracy of 0!2 of longitude and latitude is sufficient for predictions, but an accuracy of 1" or less is required for reporting observations. In your USNO total occultation predictions, you may see a "graze nearby" message for a graze which you would like to try to observe, but for which you do not have detailed predictions. If so, send me the star's Z.C., X, or C number, the approximate U.T., whether the graze is a northern or southern limit, the range of longitudes you want covered, and the aperture of the largest telescope which might be in the expedition. In addition to the detailed graze prediction and profile, I will send a set of USNO total occultation predictions computed for a point in the predicted limit closest to your station, or at a specific longitude which you request.

Of particular interest during this eclipse will be 8.7-mag. SAO 78505, since grazes at both the northern and southern limits might be observed, permitting an improved determination of the moon's polar diameter, which in turn is needed for calibrating measurements of the sun's diameter from contact and bead timings made near the edges of total solar eclipse paths. The northern limit will pass near Sept-Iles, Quebec, while the southern limit crosses the northern suburbs of Mexico City and south of Mazatlan, Mexico. Observers in both locations are needed; Paul Maley probably will lead an expedition near Mazatlan. A less favorable opportunity to measure the polar diameter involves a 10th-mag. star whose southern limit crosses the island of Hawaii, and whose northern limit lies near the southern limit for the occultation of 7.6-mag. SAO 78561 shown on my map on p. 103 of the 1982 Jan. issue of *Sky and Telescope*. In fact, these two lines intersect at Interstate 84 north of Baker, Oregon, to which Richard Linkletter is planning an expedition.

The star field map for the eclipse to be published in the December issue of *Sky and Telescope* will be similar to that for the July 6th eclipse which appeared on p. 604 of the June issue of that magazine, referred to the equinox of 1950. More details about occultations during the eclipse will be given in an issue of *o.N.* which probably will be distributed at the end of November. I plan to change the detailed maps of the eclipse field to be published in that issue, from the style that has appeared in *o.N.* for previous eclipses. The format of the map will be similar to that used for the detailed Astrographic Catalog computer-generated plots for occultations by Pluto and by (2060) Chiron and some other asteroids published in some previous issues. The scale will be expanded, so that only the field for North American observers will be shown on one page. Separate charts at the same scale will be prepared and distributed to other observers in eastern Asia and in Australia and New Zealand. I plan to include a diagram of the moon showing the major maria and craters at the same scale. The chart will be referred to the equinox of date so that stars in the detailed USNO predictions can be located from their apparent R.A. and Decl. given there. If you need to locate an object using 1950 coordinates, you can use the chart to appear in *Sky and Telescope*, and use the stars to refer back to the *o.N.* chart.

PRESENT STATUS OF INTERNATIONAL LUNAR OCCULTATION CENTER

Hydrographic Department
Tokyo, Japan

On 1981 January 1, Hydrographic Department of Japan (JHD) took over the services of international center for the receipt and processing of timings of lunar occultations from H. M. Nautical Almanac Office.

Since then, JHD
(1) set up "International Lunar Occultation Center" in the Astronomical Division,
(2) accepted 17866 timing data in total (11362 in 1981 and 6504 in 1982) as of 1982 July 31,
(3) checked and corrected these data and converted some of them into machine-readable form,
(4) computed the predictions of total and grazing occultations and sent to some institutions and groups, and
(5) edited a pamphlet "Guide to Lunar Occultation Observations" and distributed it to all the observers.

The processing of the data is now (1982 August) in progress and the results will be obtained soon.

RECENT ASTEROIDAL OCCULTATION ATTEMPTS, AND UPDATES FOR UPCOMING EVENTS

David W. Dunham

When you receive this, there will be frantic activity to obtain last-minute astrometry for, to predict final path predictions of, and to organize observations of, no less than four occultations of stars by asteroids, which are likely to be visible from North America during the third and fourth weeks of November. We hope that we will have more success with some of them than with attempts to observe three other events during the past month, which are described below along with preliminary plans for the upcoming events. Results of other asteroidal occultation attempts during 1981 and early 1982, essentially a continuation of my article in *o.N. 2* (15), 200, will be published in a future issue.

(56) Melete and SAO 139812, 1982 July 7: Gordon Taylor exposed plates at the Royal Greenwich Observatory in late May, when Melete passed close to the star. Using these data, he computed a prediction very close to my nominal prediction, ending just before sunrise near latitude +15° off the west coast of Mexico. Everhart also photographed Melete, and plates were exposed at Lowell Observatory and elsewhere, but the work of finally measuring and reduc-

ing these plates, and computing a final prediction, was not done before the event (and still has not been accomplished) due to other pressing work (the July 6th lunar eclipse for me) and the unfavorable location of Taylor's path. However, this work was unknown to Rachan Gregg, who observed at Escondido, CA, at longitude 117° 04' 06" W., latitude +33° 04' 48", height 147.4 meters, having seen the finder chart and note about the occultation in the Celestial Calendar section of the July issue of *Sky and Telescope*. Gregg wrote, "I believe I observed the occultation," noting that it started at $7^h\ 35^m\ 32^s.8$ UTC and lasted 23.3 seconds. The duration gives a chord length of 195 km, 37% larger than Melete's expected diameter. Unfortunately, I have heard of no other observations to confirm, or not confirm, this observation, which was made at a shift value of 0".87 north on my regional map on p. 210 of the last issue, and a similar amount north of Taylor's late May prediction. Peter Manly noted that clouds prevented observation from Arizona.

(57) Mnemosyne and SAO 127592, August 29: Bill Penhallow obtained plates at Quonochontaug, RI, on Aug. 27. He telephoned the coordinates determined from these plates to Robert McCutcheon, who used my computer program to calculate the path shift while I was in Greece. The result was a shift of 1".5 south ±".3, near the AGK3 path crossing northern South America shown in *O.N. 2* (15), 212.

(52) Europa and SAO 96932, September 15: Klemola obtained plates at Lick Observatory on Sept. 8 which resulted in an accurate predicted path of 0".25 north ±".05, crossing central British Columbia and northern Alberta; see the map on p. 229 of the last issue. Some observers in Washington and on Vancouver Island saw no occultation, as expected since they were all south of Klemola's path. Andrew Lowe planned to travel far north of Edmonton, and organize other observers from that city to straddle the predicted path. Unfortunately, a small weather front moved into the area a few hours before the event, producing overcast skies throughout Alberta, although it was very clear the preceding and following mornings.

(19) Fortuna and SAO 92517, September 17: Lick plates were obtained on Aug. 24, when Fortuna passed close to the star, and again on Sept. 8 and 12. Additional plates were taken with the 155-cm USNO telescope at Flagstaff, AZ, during the two nights before the occultation; positions of faint secondary reference stars from the Lick plates were used to reduce the small-field USNO plates. The final prediction from all this astrometry was a shift from my nominal path of 0".23 N ±".07, with a correction to the time of 1.3 min. early; see map on p. 230 of the last issue. The prediction apparently was accurate to a few hundredths of a second, since Harold Reitsema visually timed a 12-second occultation starting at $3^h\ 15^m\ 57^s$ U.T. using the University of Colorado's 46-cm reflector, indicating that he was very close to the southern limit, as expected; the time also agreed well with the final prediction. He noted that immersion was sharp and emersion gradual, which can be caused by different local slopes on Fortuna and the nearly grazing geometry. Haze, low altitude, and lightning from distant thunderstorms prevented photoelectric observation. Normally, clear skies prevail in the upper Midwest in September, but the same weather front which clouded out Europa two nights earlier moved southeastward so that it almost exactly covered the Fortuna occultation path, also. Consequently, Reitsema is the only known observer of the event, and many others, including the three portable photoelectric stations from Lowell Observatory, were all clouded out. Outside the path, Tony Murray used an 11-cm reflector to time a 37-second secondary occultation starting at about $3^h\ 24^m\ 00^s$. This was preceded (by about 15 sec.) by another untimed occultation of perhaps 10 sec. duration, which in turn was immediately preceded by some flickering. Unfortunately, I do not know of any others observing close enough to his path of 1".05 S to confirm or deny his report. As far as I know, I was the closest, at 0".83 S, where, observing with a 20-cm telescope, I am sure that there were no occultations of more than a few tenths of a second during the corresponding times, or any time from 3 minutes before to 15 minutes after the nominal closest approach. My finder chart for the star shows an 8th-mag. star just east of SAO 92517. Unfortunately, the 8th-mag. star is not in the SAO catalog, and therefore is not shown on either the *SAO Atlas* or *Atlas Eclipticalis*, upon which the chart in the September *Sky and Telescope* was based.

(481) Emita and SAO 110631, October 7: Lick plates taken on Aug. 24, when Emita passed close to the star before its retrograde loop, showed a large correction to the ephemeris, resulting in a path 1".8 S (crossing Iberia, Bermuda, northern Florida, and southern Texas), and 14 min. early. I sent a notice giving this result to dozens of observers near the predicted path. Klemola provided positions of secondary reference stars, which were used to reduce USNO-Flagstaff plates taken on Oct. 4 to provide a very accurate final prediction. It is a tribute to the astrometric quality of the 155-cm USNO telescope that this was possible for a 13th-magnitude asteroid which was only 12° from a 99% sunlit moon at the time. The path computed from this data was 2".74 S ±".06 (crossing southern Mexico, over Oaxaca; the Cayman Islands; eastern Cuba; and northern Africa), and 16.5 min. early. Astrometry by Taylor on Oct. 1 confirmed the large additional south shift, although his path was over a diameter north of the USNO path. We thought that the Lick results from Aug. 24 would be better than they were, but in this case, the correction to Emita's ephemeris was very large. From late Aug. to early Oct., Emita's distance from the earth had decreased substantially, and my calculations showed that the ephemeris corrections in R.A. and Decl. had grown in inverse proportion to the distance, which would be the case for a linear error in Emita's orbit. This probably will be the case generally when large ephemeris corrections are found when the asteroid passes close to the star some months before an occultation. For Emita, observers in Mexico City were notified, and they planned to contact observers in Oaxaca and possibly travel there to observe the event, if the weather was favorable. Skies were overcast throughout the south-central and eastern U.S.A., and apparently in southern Mexico as well; no observations have been reported.

(21) Lutetia and SAO 98369, October 31: Penhallow and Klemola plan astrometry for this event, but since this issue will not reach readers until afterwards, potential observers in the western U.S.A. will be contacted by phone in case of a north shift. A finder chart will be distributed separately to readers in the possible area of visibility.

(690) Wratislavia and B.D. +24° 522, November 14: Lick plates taken on Aug. 24, when Wratislavia passed near the star, indicate a 0".72 N shift (internally consistent to ±".04) with an insignificant correction to the time of 0.6 ±.6 minutes early. Although the ephemeris corrections are relatively small, if they grow inversely with the distance (as was the case for Emita on Oct. 7 discussed above), the shift will become 1".0 N. Until the objects get close enough to photograph again on the same plate, we are estimating that the path will be at 0".9 N ±".2. This path crosses the Gaspe Peninsula, Winnipeg, northwestern Montana, and the Washington-Oregon border area; see the map on p. 231 of the last issue. Since the event occurs on a Sunday morning, observers even several hundred kilometers from the path could drive to it during the weekend, and weather and astrometry permitting, I am planning an expedition to Quebec to time the occultation from different locations across the finally predicted path.

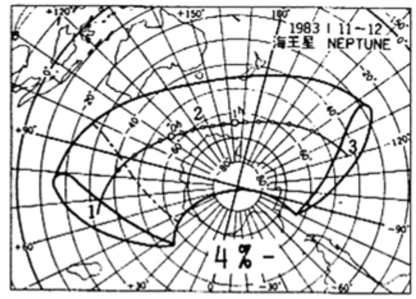
(93) Minerva and SAO 76017, November 22: Penhallow has obtained separate plates of the star and asteroid, which will decrease the considerable positional error present for both. The path predicted from these observations is 1".77 S ±".4, which can be plotted on the map on p. 233 of the last issue; the correction to the time is 1.7 ±.8 min. early. Accurate last-minute astrometry is planned for this, as well as the other November, asteroidal occultations. These updates can be obtained by calling Astro-alert in Chicago, IL, at 312, 259-2376, as is the case for any astrometrically improved asteroidal occultation prediction for North America. This occultation also probably will be visible from Europe; observers there can obtain updates from Gordon Taylor at the Royal Greenwich Observatory at 323, 833171.

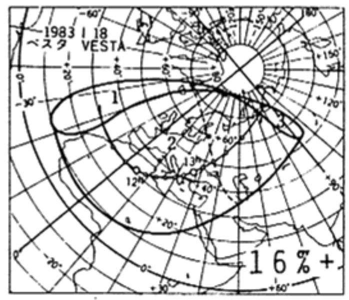
(481) Emita and SAO 110157, 1982 December 21: If the large ephemeris correction for Emita remains linear, as it did from Aug. 24 to Oct. 4, the shift for this occultation, not including any correction to the star's position, will be 3".3 west (path over the Aleutian Islands and near Midway) with the time 11 min. late. An astrometric check on both objects early in December would be useful to see if the unfavorable large west shift remains, in which case, further observational efforts will not be needed.

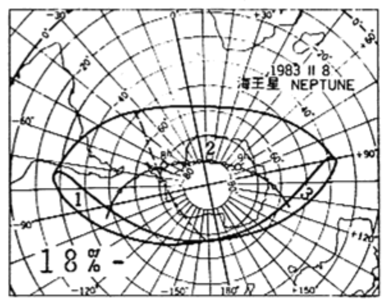
LUNAR OCCULTATIONS OF PLANETS

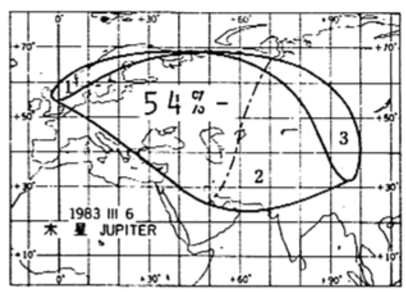
The maps showing the regions of visibility of lunar occultations of planets are reprinted by permission, from the Japanese Ephemeris for 1983, published by the Hydrographic Department of the Maritime Safety Agency of Japan. In region 1, only the reappearance is visible; in region 3, only disappearance may be seen. Reappearance occurs at sunset along a dashed curve, while disappearance is at sunrise along a curve of alternating dots and dashes. We have added a legend to each map indicating the phase of the moon at the time of the event.

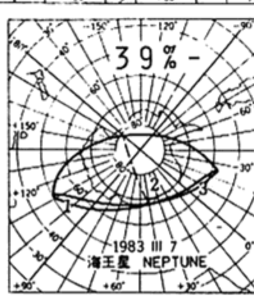
Observers interested in observing partial occultations ordinarily are expected to request predictions at least three months in advance (there is not that much time available before the first three events shown here) from Joseph Senne; P.O. Box 643; Rolla, MO 65401; U.S.A.; telephone 314, 364-6233. Perhaps the situation will have been eased for the early events by others already having entered requests.

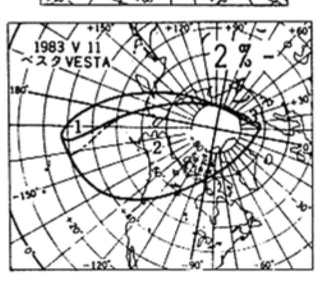


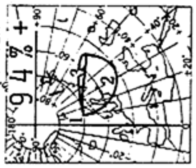


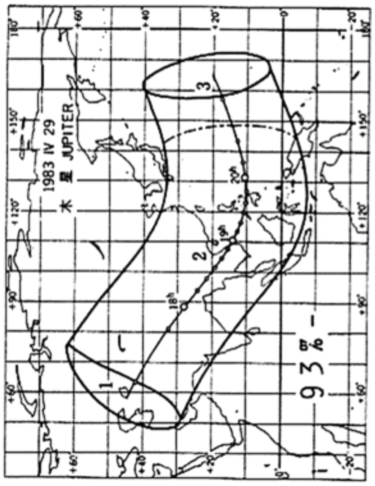









1983 VI 22
木星 JUPITER
94%+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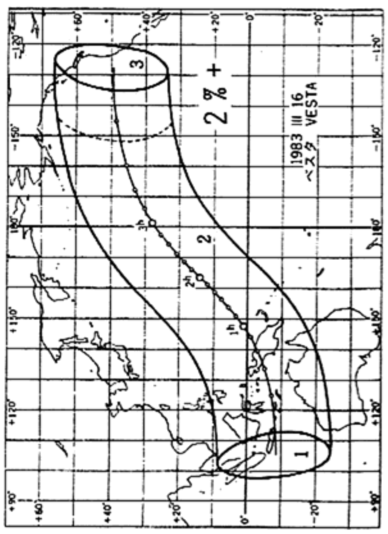
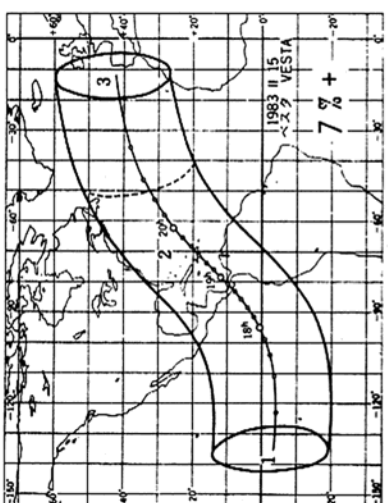
木星 JUPITER
93%-


1983 III 16
ベスタ VESTA
2%+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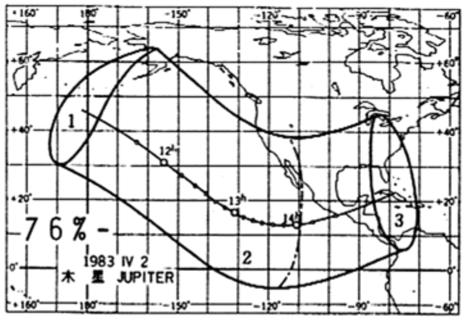
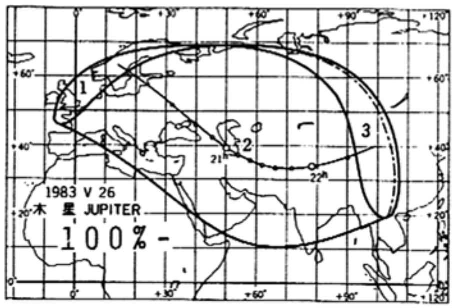
ベスタ VESTA
7%+


76%-
1983 IV 2
木星 JUPITER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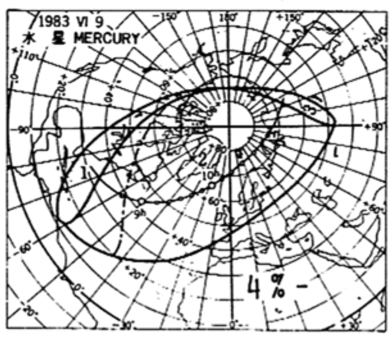
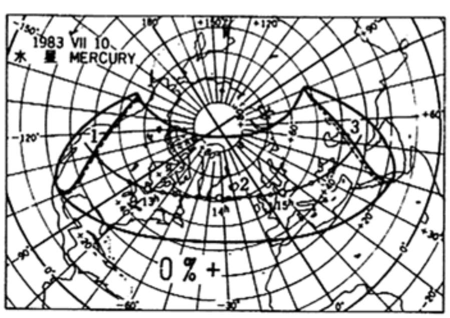
木星 JUPITER
100%-


1983 VI 9
水星 MERCURY
4%-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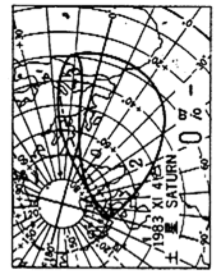
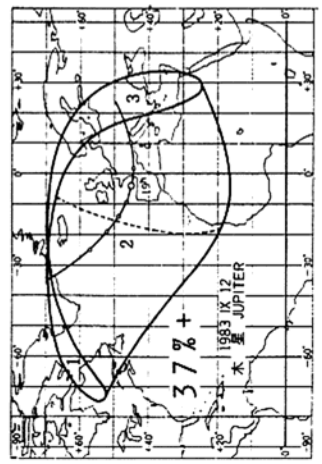
水星 MERCURY
0%+


1983 XI 4
土星 SATURN
0%-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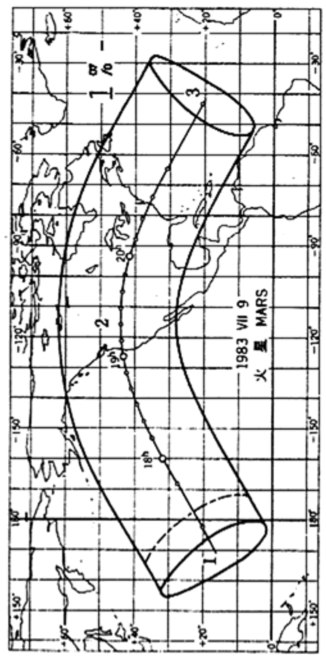
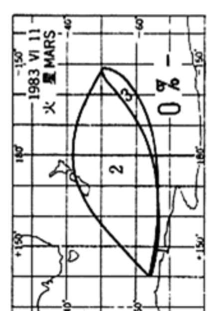
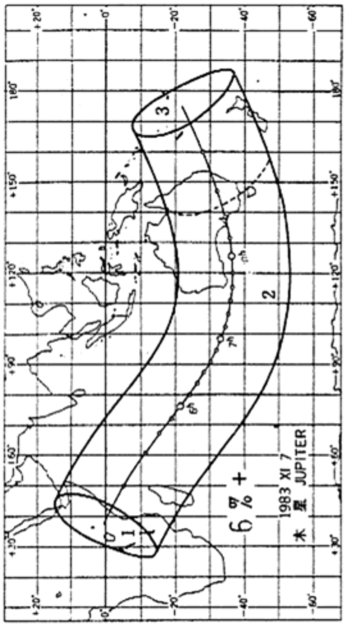
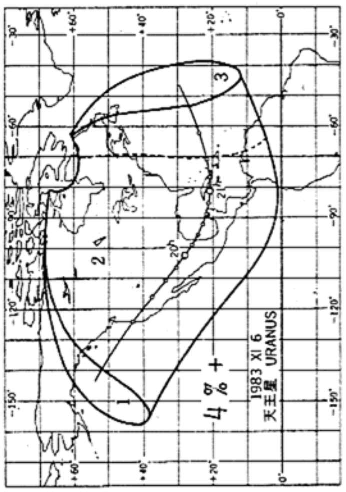
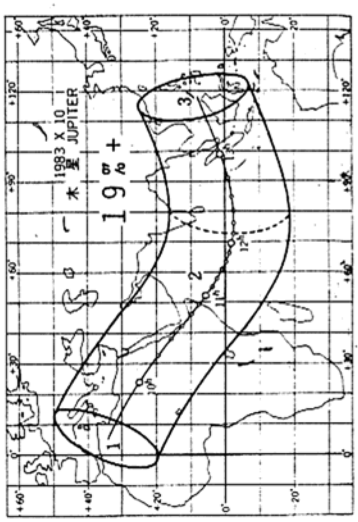
木星 JUPITER
37%+


1983 VII 9
火星 MARS
1%-


1983 VI 11
火星 MARS
0%-


1983 XI 7
木星 JUPITER
6% +


1983 XI 6
天王星 URANUS
4% +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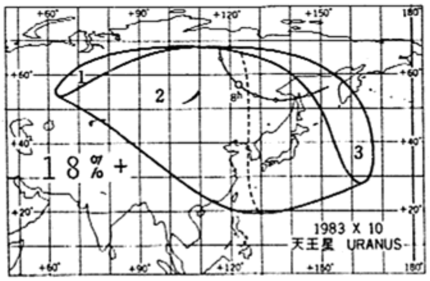
木星 JUPITER
19% +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天王星 URANUS
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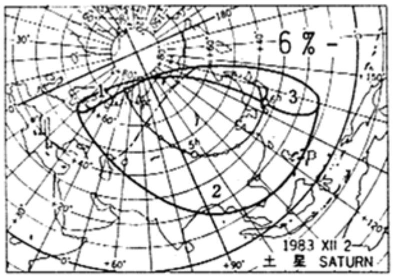
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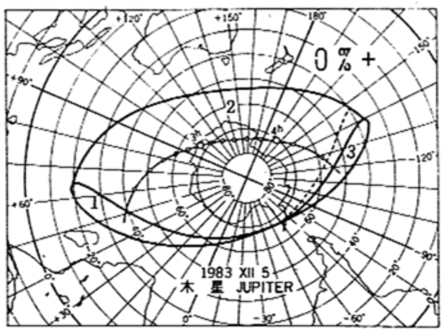
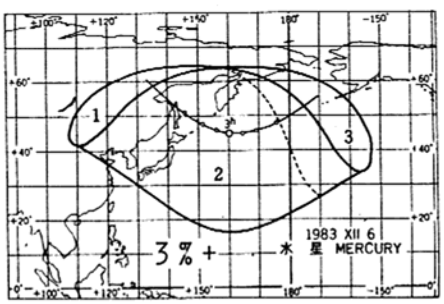
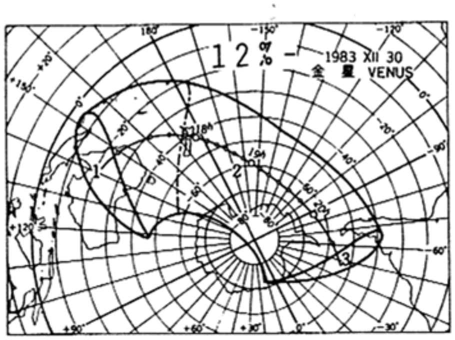
土星 SATURN
6% -


1983 XII 5
木星 JUPITER
0% +


1983 XII 6
水星 MERCURY
3% +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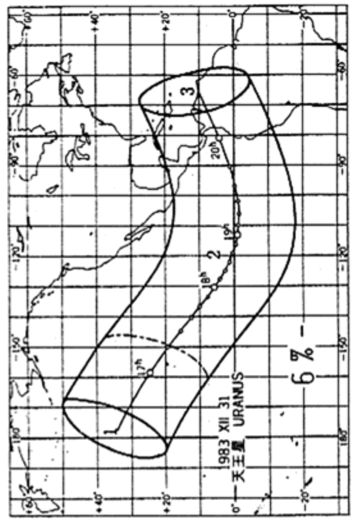
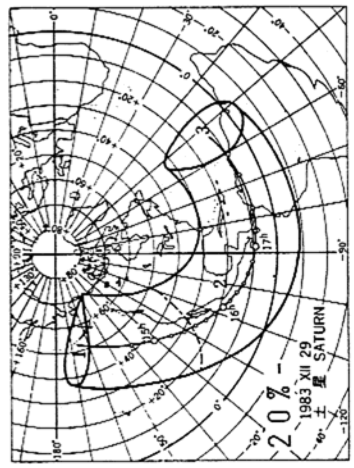
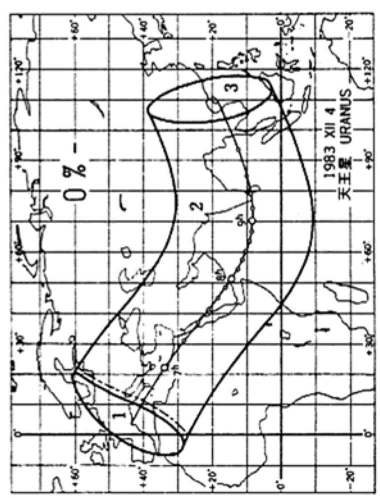
金星 VENUS
12% -


1983 XII 31
天王星 URANUS
6% -


1983 XII 29
土星 SATURN
20% -


1983 XII 4
天王星 URANUS
0% -

PLANETARY OCCULTATIONS DURING 1983

David W. Dunham

Predictions of occultations of stars by major and minor planets during 1983 are given in two tables below. Reports of observations of these events should be sent to me at P.O. Box 7488, Silver Spring, Maryland 20907, U.S.A. (telephone 301, 585-0989), with (if possible; indicate on the form to whom copies are sent) a copy to Gordon Taylor, H. M. Nautical Almanac Office, Royal Greenwich Observatory, Herstmonceux Castle, Hailsham, Sussex BN27 1RP, England. Preferably, the report forms of the International Lunar Occultation Centre (ILOC), or the equivalent IOTA/ILOC graze report forms, should be used for reporting timed occultations or appulses (we want to know if you observed, and saw nothing, but do not need a report if weather prevented effective observation). The only 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 not be sent to the ILOC in Japan. Copies of the report forms can be obtained either from the ILOC; from IOTA, address given in *O.N.* masthead; or from me. Your request will be acted upon more quickly if you send either IOTA or me a S.A.S.E.

The stellar and ephemeris data for the events listed in the tables below are discussed following the sources for the occultations and the table explanations; this is followed in turn by explanations of finder charts, and regional and world maps appearing in *O.N.*, and then information about local circumstances available from IOTA. Finally, some general observational remarks, information about prediction updates, and specific information about some of the events are given.

Sources of Planetary Occultations. Most of the events listed in the tables below were found by Gordon Taylor at the Royal Greenwich Observatory and published in his Bulletin 27 of the Working Group on Predictions of Occultations by Satellites and Minor Planets of Commission 20 (Positions and Motions of Minor Planets, Comets, and Satellites) of the International Astronomical Union (I.A.U.). The occultations by (1) Ceres, (2) Pallas, and (10) Hygiea were first published by Taylor in his article, "Occultations of Stars by the Four Largest Minor Planets, 1981-1989," in *Astron. J. 86* (6), 903-905, 1981, except for the remarkable occultation of 1 Vulpeculae by Pallas on May 29, which was first pointed out to me by Larry Wasserman, Lowell Observatory, in 1979 and first published in *O.N. 2* (7), 64-65. The occultations on Jan. 19 (Elpis); Feb. 3, 5, 19, 21, and 28; Mar. 11; Apr. 7; May 3, 9, and 24; June 10 and 28; July 4, 13, and 23 (Eugenia and Eunike); Aug. 1, 5, 6 (Eugenia), 7, 15, and 21; Sept. 1 and 11; Oct. 5 and 20; Nov. 20; and Dec. 30 (Vesta) were first published by Wasserman *et al.* in "Occultations of Stars by Solar System Objects. II. Occultations of Catalog Stars by Asteroids in 1982 and 1983," *Astron. J. 86* (12), 1974-1979, in 1981. The occultations by Uranus and by Neptune were found by Arnold Klemola, Doug Mink, and Jim Elliot by scanning Lick Observatory plates, and were published in an article, "Predicted Occultations by Uranus: 1981-1984," and in a similar article for Neptune, in *Astron. J. 86*, p. 135-40, 1981. The occultation by Uranus' satellite Umbriel on Mar. 25 was found by Mink and has been submitted, along with a list of other possible occultations of 14th and 15th-magnitude stars by the satellites of Uranus and Neptune, for publication in *Astron. J.* However, all of the information below is based on my own calculations, which sometimes differ slightly from the calculations by the others, when I use different (in my opinion, the best currently available) star positions or ephemerides.

Additional events for 1983 will be published in future issues as they become available. Probably near the beginning of the year, we can expect a list of new events from Andrew Lowe, mainly for asteroids slightly larger than 100 km probably not considered by Taylor. During the past two years, Lowe has supplied lists of additional events; see, for example, *O.N. 2* (15), 198. At the I.A.U. General Assembly in August, Lowell Observatory astronomers announced that they have found a large number of possible occultations of uncataloged stars by scanning photographic plates along the predicted paths for seven large main-belt asteroids: (1) Ceres, (10) Hygiea, (451) Patientia, (704) Interamnia, (511) Davida, (65) Cybele, and (52) Europa. Results for 1983 were presented at the American Astronomical Society's Division for Planetary Sciences meeting in Boulder, CO, in October, according to Millis *et al., Bull. Amer. Astron. Soc. 14* (3), 729.

Explanation of Data in the First Table: The ranges of Universal Time are the time of central occultation (apparent closest approach to the center of the object) and are given in increasing order. If the occultation shadow will sweep across land areas during nighttime within four minutes, only one (middle) time is given. Under PLANET, m_v is the visual magnitude (usually, photoelectric V-mag.), and Δ is the geocentric distance in astronomical units. Under STAR, m_v is the visual magnitude (converted to a photoelectric V-mag. scale using data from the SKY-MAP Catalog described in *O.N. 1* (16), 161) and Sp is the spectral type; the approximate equinox 1950 position also is given. Under OCCULTATION, Δm is the change in visual magnitude of the coalesced images which is expected if an occultation does occur, Dur is the duration for a central occultation computed using the expected diameter of the occulting object, 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 can be reduced considerably with astrometric observations, and the width of the possible area narrowed to reduce P substantially, which can be accomplished best when the planet and star can be photographed on the same plate, perhaps only 2 or 3 days before the event. Under Possible Area, the regions from which the events may occur with the sun below the horizon (unless the star is bright enough to possibly see in daylight) are listed in the chronological order in which the occultation shadow will sweep over them. A "?" indicates that an occultation will occur in the area just mentioned only if the actual path shifts n(orth) or s(outh) (the direction indicated by the letter following the "?") of the nominally predicted path, us-

Table 1, Part A.

1983 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	OCCULTATION Possible Area	El SUN	MOON El	MOON %Snl	MOON Up	Ephem. Source
Jan 19	7h22m-49m	Elpis	12.4	2.13	118599	8.8	K0	10h56m.4	2°28'	3.7	31s	54	19	Argentina,Chile; Hawaii?n(low)	134°	167°	22+	w150°W	Herget77
Jan 19	18 49-60	Dione	11.8	2.06	80228	9.1	K5	8 28.5	25 09	2.8	9	22	25	Japan,Mongolia,swUSSR,n.Europe	173	124	26+	w 40°E	EMP 1982
Jan 24	14 03	Aeria	13.8	2.77	140011	8.8	F8	14 32.2	-1 12	5.0	7	18	33	Pacific Ocean, Hawaii?n	88	151	75+	w180°	EMP 1981
Jan 27	15 23-32	Dione	11.8	2.07	80157	9.2	G5	8 21.5	25 37	2.7	9	22	25	Japan?n;s.China,n.India,Arabia	172	14	98+	all	EMP 1982
Feb 3	18 26	Fortuna	11.2	2.04		10.8	F8	2 03.0	11 40	1.0	9	11	13	nwAfrica,eMediterranean,Mideast	79	176	61-	none	EMP 1981
Feb 5	9 49	Eugenia	12.4	3.06	160906	8.9	F5	17 52.7	-18 12	3.6	6	9	18	NC, VA (low); Bermuda	48	36	44-	all	Herget77
Feb 12	21 07	Ceres	9.2	3.74	188703	9.4	G5	19 51.9	-24 41	0.7	24	9	5	sw Australia?n	28	26	0-	none	APAENAXX
Feb 14	18 52-81	Kassandra	12.0	1.64	95572	6.4	K0	6 18.5	17 47	5.6	47	91	18	e. India, w. & n. China	129	108	3+	none	Herget78
Feb 19	23 34	Patientia	12.8	3.68	186447	9.5	A0	18 08.9	-20 35	3.4	9	12	19	Madagascar; s. India?n	58	139	42+	none	Herget78
Feb 21	11 23-36	Elpis	11.9	1.94		11.3	K2	10 37.1	5 27	1.1	12	20	17	s.Mexico?n;Hawaii?s;se.Siberia	172	87	58+	w150°W	Herget77
Feb 27	19 04	Antigone	13.3	3.96		11.2	G0	1 53.4	0 33	2.3	3	11	51	Britain, Scandinavia	49	138	100-	all	EMP 1980
Feb 28	17 35	Davida	12.7	4.20	162050	6.3	G5	18 56.5	-18 38	6.4	11	13	18	Queensland; New Zealand?s	56	105	97-	all	EMP 1982
Mar 2	14 56-74	Hippo	12.7	2.00	79122	9.2	K0	7 06.6	26 36	3.6	17	37	23	Japan?w; Australia?w	124	99	86-	all	Herget
Mar 3	20 44-62	Uranus-R	5.6	18.84		10.4	K2	16 27.6	-21 38	.08	155m	158	1	Australia, Asia	94	28	76-	all	NA0001
Mar 6	12 23	Undina	12.3	3.61	110445	9.0	K0	2 14.0	6 18	3.4	5s	10	28	Mongolia, Manchuria	49	139	50-	none	Herget78
Mar 6	14 53-68	Meliboea	13.7	2.97		9.8	A2	8 30.1	2 58	4.0	12	27	28	NewZlnd, Austrl, Java?n; India	141	126	49-	e125°E	EMP 1982
Mar 7	6 23	Merapi	14.2	3.64	185773	9.2	F0	17 45.0	-27 26	5.0	7	17	35	Brazil?s; Gulf of Guinea	79	6	43-	all	Herget81
Mar 8	3 31	Chicago	13.8	3.83	161056	6.8	B9	18 02.6	-19 46	7.0	9	17	28	s. Europe?n; n. Africa	76	5	35-	all	EMP 1983
Mar 11	19 16	Fortuna	11.5	2.45	93315	8.0	A0	3 07.5	16 37	3.6	6	9	16	w. & cen. Europe, Black Sea	59	92	8-	none	EMP 1981
Mar 17	21 21-30	Aeneas	15.5	4.42	156569	9.4		11 13.2	-16 05	6.1	7	24	49	s.Asia,e.Mediterran'n,w.Europe	161	136	10+	w 5°W	Herget78
Mar 24	15 03-41	Astraea	9.8	1.21		11.0	G0	10 29.9	13 52	0.3	24	45	15	Micronesia, China, Kazakhstan	151	27	78+	w170°E	ITA-B151
Mar 25	2 00-20	Uranus	5.5	18.49		10.4	K2	16 27.6	-21 38	.08	161m	163	1	S. America, Europe, Africa	115	115	82+	w 10°E	NA0001
Mar 25	16 22-42	Umbriel	15.3	18.48		10.4	K2	16 27.6	-21 38	4.9	155s	118	24	Samoa, Fiji, Australia	115	107	87+	w155°E	Mink
Mar 28	16 36	Pallas	10.1	3.24	104460	9.2	A2	19 03.1	12 06	1.3	23	15	9	se. Australia?n; New Zealand	80	98	100-	all	Sitarski
Mar 29	9 44	Winchester	13.7	3.53	162712	7.0	F8	19 28.2	-11 35	6.8	9	17	25	Caribbean, s. Mexico	76	95	99-	all	Herget78
Apr 4	14 52	Hispania	12.4	2.29	228439	9.3	A0	17 45.2	-41 29	3.1	14	24	19	Hawaii?s	106	19	57-	all	Herget
Apr 7	6 25	Herculina	10.2	2.20	161669	9.5	B9	18 34.3	-12 57	1.2	18	24	15	Colombia, n. Brazil	98	31	32-	e 70°W	Herget
Apr 12	15 51-60	Eva	13.1	2.12	186949	8.1	G5	18 29.7	-22 11	5.0	9	23	28	Philipp.Is,Melanesia;NewZlnd?s	105	97	1-	none	Herget
Apr 21	5 14-24	Niobe	11.7	2.15	98016	9.1	K0	8 37.2	10 02	2.7	10	27	29	HI?s; CA, Mexico?n; Peru (low)	99	12	60+	all	Herget77
Apr 23	20 09	Freia	13.1	2.86	97183	9.0	K0	7 40.6	19 24	4.2	9	15	21	Canary Islands, n. Africa	81	55	86+	all	EMP 1980
Apr 24	13 44	Pluto	13.7	28.93		15.0		14 07.2	5 49	0.3	128	45	14	AK; (HI, e.Asia, Australia)?s	162	31	91+	w140°W	NA0001
Apr 28	16 08-28	Beatrix	12.3	1.69	187286	7.2	B9	18 44.5	-28 20	5.1	22	48	21	Japan, Samoa	117	46	98-	all	Herget78
May 2	13 32-42	Lydia	12.4	2.06	119287	8.9	K0	12 12.7	4 52	3.5	14	39	29	New Zealand?n; Tasmania?n	140	102	74-	all	EMP 1977
May 3	11 36-59	Penelope	12.8	2.21		11.6	F8	12 06.4	4 22	1.5	13	40	35	Tahiti,Micronesia,Taiwan,eChina	137	114	66-	e170°E	EMP 1981
May 4	22 18-30	Pallas	9.9	2.88	104751	8.6	G0	19 18.7	18 04	1.6	40	25	8	s&eAfr?w;Iran,swUSSR,Scand'via	104	46	52-	e 50°E	Sitarski
May 6	2 36-42	Niobe	11.8	2.32	117178	8.4	G5	8 47.3	8 28	3.4	6	18	32	Mexico?n;Peru, Bolivia,swBrazil	87	161	41-	none	Herget77
May 9	12 40-50	Interamnia	11.5	2.57	204221	9.4	G0	13 09.0	-31 04	2.3	24	22	11	New Zealand, Australia, seAsia	151	146	12-	none	EMP 1977
May 14	10 59-70	Brixia	14.0	2.49	159459	7.2	F5	15 40.3	-10 46	6.8	8	19	27	sMexico;(swUSA,Hawaii,Japan)?n	171	160	4+	w135°E	EMP 1982
May 24	12 12-19	Melpomene	11.3	2.51	99225	8.2	K0	10 36.1	14 17	3.2	11	23	25	Indonesia,Queensland,NewCaledonia	93	59	94+	all	Herget78
May 29	4 42-59	Pallas	9.7	2.69	87010	4.8	B5	19 14.1	21 18	4.9	46	27	7	S. Africa?n; FL, TX, n. Mexico	120	48	94-	e122°W	Sitarski
Jun 1	20 35-47	Terpsichore	14.1	2.49	183183	8.0	K2	15 03.9	-26 38	6.1	9	23	30	Sri Lanka,n.Africa,sw.Europe?n	159	86	69-	e 40°E	EMP 1979
Jun 10	8 49	Juno	10.0	2.46	109280	9.3	K2	0 31.5	4 36	1.2	9	10	13	ne. North America?s	69	58	1-	e 77°W	APAENAXX
Jun 12	15 59-64	Germania	13.4	3.23		10.5	K0	11 08.2	-0 37	3.0	12	22	25	Kenya; (s. India, Sumatra)?n	88	68	3+	w 50°E	EMP 1981
Jun 15	9 16-26	Beatrix	11.5	1.37	210241	8.1	K2	18 27.1	-31 00	3.5	13	25	17	Midwest,swUSA,nwMexico,Hawaii	165	135	23+	w160°W	Herget78
Jun 15	14 42-52	Neptune	7.9	29.25		10.9		17 49.2	-22 09	.64	35m	45	1	HI,N.Zealand,Australia,se.Asia	176	123	26+	w 90°E	NA0001
Jun 28	12 23-55	Iris	9.4	1.74	185215	9.1	F8	17 13.3	-22 07	0.9	18s	21	11	Hawaii?n; Philippines, swChina	163	52	91-	e125°E	Branham
Jul 4	20 23	Cybele	11.4	2.16	163675	9.2	M1	20 30.6	-15 46	2.4	33	31	10	se. Australia	156	82	37-	all	EMP 1975
Jul 13	18 11	Ligura	12.8	2.26		10.6	F8	1 23.3	9 18	2.3	8	14	21	New Zealand?n	88	133	15+	none	Herget78
Jul 19	18 16-31	Princetonia	12.9	2.21	213361	8.5	K5	21 50.0	-33 27	4.4	13	27	23	eIndonesia;nwAustrl?s;S.Afr.	151	82	76+	w120°E	EMP 1982
Jul 23	9 05-25	Eugenia	10.8	1.59	162591	9.1	A5	19 22.4	-16 01	1.9	24	24	9	nwS.America;N.Zealand?s;Austrl	169	11	98+	all	Herget77
Jul 23	16 28	Messalina	13.4	2.20		11.4	G5	0 17.6	5 13	2.2	16	44	30	New Zealand?n	114	81	98+	all	EMP 1982

ually by at least a few tenths of an arc second in the sky. The elongation of the sun from the planet is given under El Sun. Under MOON, the elongation from the planet is given under El, the percent sunlit ("+" for waxing and "-" for waning phases) is given under % Snl, and the approximate longitudes from which the moon will be above the horizon in the possible area are specified under Up. For the latter, the moonrise or moonset terminator is specified in degrees of longitude E(ast) or 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

Table 2, Part A.

1983	M I N O R	P L A N E T					MOTION		S T A R			STELLAR DIAMETER					COMPARISON DATA			A P P A R E N T	
DATE	No.	Name	km-diam.	-"	RSOI	Type	°/Day	PA	SAO No	DM No.	D	M"	M	Time	df	S	AGK3 No	Shift	Time	R.A.	Dec.
Jan 19	59	Elpis	165	0.11	791	C	0.082	305°	118599	+02°2374	K	0.37	571	108	2.0	XA	N02°1445	$0''.81$	$0^{m}.7$	$10^{h}58^{m}.1$	2°17'
Jan 19	106	Dione	118	0.08	501	U	0.211	288	80228	+25 1937		0.52	769	59	2.7	XA	N25 989	-0.12	-0.0	8 30.5	25 02
Jan 24	369	Aeria	120	0.06	491	CMEU	0.213	93	140011	-00 2845		0.13	266	15	0.8	PA	S 1 1848	-0.68	-0.2	14 33.9	-1 20
Jan 27	106	Dione	118	0.08	504	U	0.208	285	80157	+25 1915		0.49	729	56	2.6	XA	N25 977	-0.10	-0.9	8 23.5	25 30
Feb 3	19	Fortuna	226	0.15	912	C	0.419	71				0.05	75	3	0.3	XA	N11 201	0.01	0.0	2 04.8	11 50
Feb 5	45	Eugenia	250	0.11	1273	C	0.425	89	160906	-18 4684		0.11	245	6	0.7	X				17 54.6	-18 12
Feb 12	1	Ceres	1025	0.38	12282	C	0.384	84	188703	-2415676		0.11	296	7	0.8	X				19 53.9	-24 35
Feb 14	114	Kassandra	131	0.11	461	C	0.056	347	95572	+17 1214		1.08	1280	462	5.1	ZA	N17 606	-0.02	0.2	6 20.4	17 46
Feb 19	451	Patientia	281	0.11	1987	C	0.280	95	186447	-20 5024		0.02	64	2	0.2	X				18 10.8	-20 35
Feb 21	59	Elpis	165	0.12	799	C	0.232	301		+05 2371		0.12	165	12	0.6	XA	N 5 1549	0.01	-0.0	10 38.8	5 17
Feb 27	129	Antigone	113	0.04	525	U	0.287	64		+00 311		0.05	132	4	0.3	A	N 0 173			1 55.1	0 42
Feb 28	511	Davida	335	0.11	2949	C	0.240	88	162050	-18 5155	X	0.70	2129	70	5.3	YZ		1.46	-1.0	18 58.4	-18 36
Mar 2	426	Hippo	126	0.09	488	C	0.125	191	79122	+26 1470		0.30	438	58	1.6	XA	N26 769	0.37	1.7	7 08.6	26 33
Mar 3		Uranus	50300	3.68	*****		0.010	99		-2164352		0.08	1134	210	1.3	H				16 29.5	-21 42
Mar 6	92	Undina	184	0.07	980	U	0.338	64	110445	+05 309		0.33	863	23	2.3	SA	N 6 239	-0.30	0.4	2 15.8	6 27
Mar 6	137	Meliboea	153	0.07	926	C	0.140	310		+03 2001		0.04	87	7	0.3	A	N 2 1149			8 31.9	2 51
Mar 7	536	Merapi	152	0.06	866	C	0.198	110	185773	-2711940		0.08	215	10	0.6	X				17 47.0	-27 26
Mar 8	334	Chicago	199	0.07	1343	C	0.199	88	161056	-19 4832		0.15	418	18	1.1	PZ		0.07	-0.1	18 04.5	-19 45
Mar 11	19	Fortuna	226	0.13	928	C	0.482	75	93315	+16 398		0.09	169	5	0.5	XA	N16 274	-1.16	-1.1	3 09.3	16 45
Mar 17	1172	Aeneas	131	0.04	1037	D	0.131	298	156569	-15 3226						S				11 14.8	-16 16
Mar 24	5	Astraea	116	0.13	344	S	0.131	305		+14 2256		0.05	44	9	0.2	XA	N13 1052	0.02	0.0	10 31.7	13 42
Mar 25		Uranus	50300	3.75	*****		0.009	279		-2164352		0.08	1113	214	1.3	H				16 29.5	-21 42
Mar 25		Umbriel	1110	0.08	90205		0.013	239		-2164352		0.08	1112	155	1.3	H				16 29.5	-21 42
Mar 28	2	Pallas	538	0.23	5190	U	0.239	49	104460	+11 3725		0.05	128	5	0.4	SA	N12 2061	0.02	1.4	19 04.6	12 09
Mar 29	747	Winchester	208	0.08	1324	C	0.207	79	162712	-11 5025		0.28	712	32	1.9	YG		-1.54	1.1	19 30.0	-11 31
Apr 4	804	Hispania	175	0.11	816	C	0.182	130	228439	-41 8258		0.11	180	14	0.6	S				17 47.6	-41 30
Apr 7	532	Herculina	217	0.14	1046	S	0.182	90	161669	-13 5051		0.04	66	5	0.2	S				18 36.2	-12 55
Apr 12	164	Eva	111	0.07	386	C	0.192	121	186949	-22 4767		0.20	301	25	1.0	YX		-2.48	-4.7	18 31.7	-22 09
Apr 21	71	Niobe	106	0.07	353	S	0.164	128	98016	+10 1846		0.32	499	47	1.7	SA	N10 1124	1.24	-0.4	8 39.0	9 55
Apr 23	76	Freia	196	0.09	1017	P	0.259	97	97183	+19 1807		0.26	543	24	1.6	XA	N19 757	-0.16	0.4	7 42.5	19 19
Apr 24		Pluto	3000	0.14	*****		0.027	288								R				14 08.8	5 40
Apr 28	83	Beatrix	118	0.10	384	C	0.105	117	187286	-2814997		0.18	222	42	0.9	YZ		0.16	2.2	18 46.6	-28 18
May 2	110	Lydia	102	0.07	386	M	0.115	271	119287	+05 2603		0.27	410	57	1.4	XA	N 4 1595	-0.22	-0.4	12 14.4	4 41
May 3	201	Penelope	92	0.06	345	M	0.109	294		+04 2579		0.04	57	8	0.2	XA	N 4 1586	-0.01	-0.1	12 08.1	4 11
May 4	2	Pallas	538	0.26	5272	U	0.155	6	104751	+17 3934		0.17	360	27	1.1	SA	N18 1844	-0.51	2.2	19 20.2	18 08
May 6	71	Niobe	106	0.06	350	S	0.233	119	117178	+08 2127		0.26	443	27	1.5	SA	N 8 1189	0.73	-0.2	8 49.1	8 20
May 9	704	Interamnia	338	0.18	2789	F	0.182	313	204221	-3010396		0.11	197	14	0.6	S				13 10.9	-31 15
May 14	521	Brixia	136	0.08	714	C	0.214	277	159459	-10 4149		0.26	470	29	1.5	YG		1.13	0.9	15 42.2	-10 53
May 24	18	Melpomene	148	0.08	638	S	0.176	110	99225	+14 2277		0.32	577	43	1.8	XA	N14 1140	0.31	0.6	10 37.8	14 06
May 29	2	Pallas	538	0.28	5318	U	0.146	316	87010	+21 3713	A	0.32	615	52	1.9	HA	N21 1949	0.88	-0.8	19 15.5	21 21
Jun 1	81	Terpsichore	122	0.07	599	C	0.182	287	183183	-2610710		0.55	989	72	3.2	PS		0.38	1.6	15 05.9	-26 46
Jun 10	3	Juno	267	0.15	1299	S	0.413	75	109280	+04 75		0.29	515	17	1.7	XA	N 4 60	-0.71	0.2	0 33.2	4 47
Jun 12	241	Germania	187	0.08	1101	C	0.162	104		-00 2413		0.13	307	19	0.9	XA	S 0 1583	-0.31	-0.2	11 09.9	-0 48
Jun 15	83	Beatrix	118	0.12	391	C	0.226	259	210241	-3115599		1.76	1748	186	7.6	S				18 29.3	-30 58
Jun 15		Neptune	50184	2.37	*****		0.027	271		-2258794		0.23	4934	207	4.6	H				17 51.2	-22 09
Jun 28	7	Iris	222	0.18	1164	S	0.233	282	185215	-2211941		0.11	141	12	0.5	X				17 15.3	-22 09
Jul 4	65	Cybele	311	0.20	2201	C	0.144	254	163675	-16 5634		0.69	1089	116	3.8	X				20 32.4	-15 39
Jul 13	356	Ligura	157	0.10	618	C	0.305	60				0.06	92	4	0.3	XA	N 9 132	0.01	0.0	1 25.0	9 28
Jul 19	508	Princetonia	139	0.09	662	C	0.164	233	213361	-3315798		3.56	5701	521	19.4	S				21 52.0	-33 18
Jul 23	45	Eugenia	250	0.22	1319	C	0.214	249	162591	-16 5303		0.06	74	7	0.3	X				19 24.3	-15 57
Jul 23	545	Messalina	105	0.07	383	C	0.101	23		+04 34		0.07	106	16	0.4	A	N 5 30			0 19.4	5 24

whether the moon is up, or not, respectively, in the entire possible area 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 most asteroids, I have generated the ephemeris by numerically integrating the orbital elements given in the specified source. For the major planets, NA0001 is a U. S. Naval Observatory data set; empirical corrections have been added in the case of Neptune to make it agree with the better Jet Propulsion Laboratory's DE96 ephemeris. The orbital elements by the late Paul Herget, Cincinnati Observatory, all have been published in the *Minor Planet Circulars* (M.P.C.'s), numbers 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*, while ITA-B stands for their *Institute of Theoretical Astronomy Bulletin*, followed by its number. APAENAXX refers to *Astronomical Papers Prepared for use of the American Ephemeris and Nautical Almanac* 20. Some orbital elements were supplied by R. Branham, U. S. Naval Observatory, in 1977, before he published them in the *Astron J.* Orbital elements by Schmadel (Astronomisches Rechen-Institut, Heidelberg, German Federal Republic) and Sitarsky (Poland) have been published in recent M.P.C.'s. Kris-

Table 1, Part B.

1983 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	OCCULTATION Possible Area	El SUN	MOON El	MOON %Snl	MOON Up	Ephem. Source
Jul 23	21^h35^m-42^m	Eunike	12.9	2.82	101045	7.7	K0	$14^h26^m.6$	11°16'	5.3	11^s	20	22	U.K., w. Europe, n. Africa	90°	80°	99+	all	Herget77
Aug 1	0 04	Eunomia	11.3	3.50	157161	8.8	F8	12 11.9	-12 44	2.6	9	12	19	Chile, Argentina, Uruguay	61	157	61-	none	Branham
Aug 3	20 51-65	Harmonia	9.7	1.24	188145	9.7	F5	19 24.6	-25 16	0.8	16	29	15	Kazakhstan, Mideast, n. Africa	158	134	31-	e 48°E	Herget78
Aug 3	21 57-78	Hersilia	12.8	1.87	146454	7.7	K0	22 59.2	-7 14	5.1	15	36	24	w.China, India, central Africa	147	80	30-	e 45°E	EMP 1982
Aug 5	1 07	Winchester	12.2	2.09	162242	9.3	K5	19 06.2	-15 22	2.9	15	21	15	eastern North America?s	154	152	19-	none	Herget78
Aug 6	0 39-49	Diana	12.8	2.20	188283	9.1	G5	19 31.0	-29 16	3.7	11	23	23	South Africa?n; Patagonia	156	162	11-	none	Herget77
Aug 6	18 42-62	Eugenia	11.0	1.65	162357	9.4	G5	19 11.9	-17 06	1.9	31	31	10	seChina,Indoch',SriLnka,S.Afr'	153	172	5-	none	Herget77
Aug 7	3 51-64	Lucina	11.7	1.69	212325	9.5	K0	20 36.9	-33 30	2.3	14	24	16	southern Africa, Antarctica	162	163	4-	e 22°E	EMP 1981
Aug 8	6 36	Hygiea	10.6	2.83	158213	9.4	F8	13 50.4	-14 30	1.5	18	13	9	Tahiti	76	84	1-	none	Schmadel
Aug 13	13 40-46	Boliviana	13.5	2.52	159867	6.6	F0	16 17.7	-12 48	6.9	19	47	29	northern Australia	105	39	30+	w130°E	EMP 1982
Aug 15	10 54-73	Cybele	11.4	2.18	163239	9.2	K2	20 02.1	-17 56	2.4	32	30	10	Calif.(low), Hawaii, Indonesia	157	68	49+	w170°W	EMP 1975
Aug 20	20 26	Terpsichore	15.0	3.38	183178	9.3	G5	15 03.6	-24 51	5.7	7	21	40	central Africa	84	66	93+	all	EMP 1979
Aug 21	5 34	Palma	11.8	2.08	74064	8.8	F8	0 29.0	23 26	3.1	16	24	15	nwAfrica,CanaryIs.;neN.Amer.?w	128	77	95+	none	Herget77
Sep 1	0 51	Lachesis	12.9	2.58	208888	8.8	A0	17 27.0	-30 13	4.1	17	31	21	eastern N. America (twilight)	105	169	44-	none	EMP 1980
Sep 1	19 42	Loreley	13.5	3.65	59132	9.4	A5	6 25.5	30 19	4.1	8	13	23	Philippines, Micronesia	63	12	35-	all	Herget78
Sep 11	7 44-60	Nemausa	10.6	1.52	146780	5.9	A2	23 31.6	-1 31	4.8	13	20	14	se U.S.A., Mexico; Tahiti?s	174	128	23+	w150°W	Kristensen
Sep 12	19 10-95	Neptune-R	7.9	30.12		12.7		17 42.7	-22 10	0.13	362^m	468	1	S. America, Europe, Africa	97	24	36+	w 30°E	NA0001
Sep 13	8 59	Aurora	13.7	3.75	183331	9.4	A5	15 13.8	-24 51	4.3	7^s	13	28	sw Australia?n; New Zealand	63	20	43+	all	EMP 1981
Sep 14	6 21	Aletheia	13.9	3.51	77803	8.6	G5	5 55.9	20 40	5.2	6	20	49	Argentina, southern Brazil	81	173	52+	none	Herget81
Oct 1	21 04	Lachesis	13.2	3.02	185970	8.9	A3	17 53.4	-29 03	4.3	8	15	25	southern Africa	81	144	28-	none	EMP 1980
Oct 5	11 54-66	Palma	11.2	1.77		11.4	G5	23 48.1	27 24	0.7	15	20	13	HI;(Japan,seChina)?n;Indochina	154	147	2-	none	Herget77
Oct 8	9 43	Hygiea	10.8	3.47	183401	7.9	M2E	15 18.5	-20 13	3.0	11	9	11	seAustralia?n;NewZealnd?n(low)	38	14	5+	w160°E	Schmadel
Oct 9	15 14	Atalante	11.8	1.54	41289	9.4	F8	6 39.5	44 54	2.5	7	14	18	Philippines, Japan, e. Siberia	97	134	13+	none	Herget78
Oct 14	4 26	Pandora	13.0	3.21		9.4	F0	9 39.8	20 12	3.7	4	12	41	northwestern Africa	59	153	54+	none	Herget78
Oct 20	4 42	Hebe	10.4	2.43	161267	6.5	OE5	18 14.5	-18 29	3.9	6	11	19	Tahiti?n	68	93	97+	all	Branham
Oct 23	5 30-35	Hispania	12.6	2.73	210091	1.8	A0	18 20.9	-34 25	10.8	6	10	23	(nAustralia,Fiji)day;Hawaii?n	66	128	98-	e160°W	Herget78
Oct 27	16 26	Aemilia	14.1	3.31	188979	9.2	K5	20 07.2	-20 32	4.9	8	21	34	Sudan, Yemen, western India	86	164	56-	e 80°E	EMP 1982
Nov 12	13 19	Europa	12.1	3.74	139084	8.7	K2	12 56.8	-0 50	3.5	7	9	19	western Canada?s	36	125	49+	none	Herget78
Nov 19	19 46	Herculina	11.3	3.47	187978	9.0	F5	19 16.9	-25 59	2.4	6	10	23	South Africa?n	51	120	99+	all	Herget78
Nov 20	10 55	Hebe	10.4	2.68	187870	9.2	F0	19 11.7	-20 00	1.5	5	9	21	northern Australia	50	129	100+	all	Branham
Nov 20	13 31-45	Chaldaea	12.0	1.41	129646	8.8	F8	2 00.1	-1 52	3.3	14	30	19	e.Siberia,Sinkiang,Afghanistan	148	32	100-	all	Herget78
Nov 24	15 08-30	Messalina	13.8	2.44	128200	8.6	K0	23 25.9	5 32	5.2	18	52	34	Arabia, Pakistan, China, Japan	113	119	80-	e 80°E	EMP 1982
Dec 1	20 28	Mars	1.5	1.90	138836	7.6	G0	12 29.5	-1 30	0.0	205	8	1	seAsia,Philippines,wAustralia	61	28	8-	e105°E	NA0001
Dec 5	20 41-49	Mashona	13.9	2.65		10.7		3 42.4	50 06	3.3	8	21	33	Sri Lanka,e.central & s.Africa	150	144	2+	none	EMP 1982
Dec 10	3 21-27	Ino	13.2	2.88		10.5	G0	11 10.3	5 14	2.8	12	25	25	northeastern Brazil, Zaire	91	154	28+	none	Herget78
Dec 25	0 59-69	Erato	14.2	2.94	118937	9.4	F2	11 33.3	4 13	4.8	13	38	38	Canary Islands,n.Africa,Arabia	100	14	70-	all	EMP 1981
Dec 25	15 36-47	Siwa	12.9	2.16		10.2	A3	5 15.4	21 14	2.7	8	21	30	N.Zlnd(low),sAustrl;M'ritius?n	167	88	63-	e118°E	Herget77
Dec 26	20 55-65	Euterpe	10.8	1.61		10.6	G5	11 30.2	4 53	0.9	10	22	20	Arabia,India,seAsia,Philipp'ns	103	14	49-	all	Herget77
Dec 30	14 01-18	Vesta	6.8	1.63		10.7	F8	5 01.2	19 02	0.03	50	23	4	Hawaii?n; Japan, China, Iran	158	159	13-	e158°W	APAENAXX
Dec 30	22 48-76	Aegina	12.0	1.41	76615	9.1	A0	4 24.5	24 57	3.0	17	38	19	central Africa, Brazil	150	171	11-	none	EMP 1982

tensen (University of Aarhus, Denmark) supplied ephemerides for (51) Nemausa.

One of the most important columns in the table is Δm, since it specifies the observability of the event. A value much less than 1.0 in general means that the event can be reliably observed only photoelectrically; during the occultation by (3) Juno in 1979 Dec. 11, a Δm of 0.4 was timed visually, but photoelectric data showed that the reaction times were 1 second or more. For the occultations by Uranus and Neptune, the Δm is for the photoelectric infrared I-magnitude, to take advantage of the planet's methane absorption bands in the infrared; the Δm is much smaller, usually unobservable, at visual wavelengths. For occultations by these planets, only an occultation by possible rings, and not by the planet itself, is possible if the name is followed by "-R."

Table 2, Part B.

1983 DATE	No.	MINOR PLANET Name	km-diam.	-"	RSOI	Type	MOTION °/Day	PA	STAR SAO No	DM No.	D	STELLAR DIAMETER M"	M	Time	df	S	COMPARISON DATA AGK3 No	Shift	Time	APPARENT R.A.	Dec.
Jul 23	185	Eunike	188	0.09	998	C	0.196	140°	101045	+11°2684		0.61	1251	75	3.8	SA	N11°1583	-0".22	$1^m.2$	$14^h28^m.2$	11°07'
Aug 1	15	Eunomia	261	0.10	1702	S	0.281	106	157161	-12 3589		0.13	337	11	0.9	PS		-0.05	1.1	12 13.6	-12 55
Aug 3	40	Harmonia	118	0.13	366	S	0.202	254	188145	-2514064		0.08	69	9	0.3	X				19 26.6	-25 12
Aug 3	206	Hersilia	111	0.08	419	C	0.132	237	146454	-07 5911		0.48	648	86	2.4	PX		-0.07	0.2	23 00.9	-7 03
Aug 5	747	Winchester	208	0.14	1173	C	0.213	237	162242	-15 5247		0.48	725	54	2.5	S				19 08.1	-15 19
Aug 6	78	Diana	140	0.09	672	C	0.189	275	188283	-2916291		0.19	299	24	1.0	S				19 33.1	-29 12
Aug 6	45	Eugenia	250	0.21	1325	C	0.162	243	162357	-17 5534		0.17	206	25	0.8	X				19 13.8	-17 03
Aug 7	146	Lucina	153	0.12	652	C	0.213	245	212325	-3315114		0.21	255	23	1.0	S				20 39.0	-33 23
Aug 8	10	Hygiea	443	0.22	3321	C	0.292	106	158213	-14 3822		0.10	204	8	0.6	X				13 52.2	-14 40
Aug 13	712	Boliviana	128	0.07	549	C	0.088	104	159867	-12 4480		0.28	508	76	1.6	PG		-0.92	-2.3	16 19.5	-12 52
Aug 15	65	Cybele	311	0.20	2218	C	0.146	250	163239	-18 5586		0.30	474	49	1.6	X				20 04.0	-17 50
Aug 20	81	Terpsichore	122	0.05	593	C	0.168	98	183178	-2411857		0.17	426	25	1.2	S				15 05.6	-24 59
Aug 21	372	Palma	196	0.13	997	CEU	0.191	328	74064	+22 75		0.12	177	15	0.6	SA	N23 50	-0.44	0.4	0 30.8	23 37
Sep 1	120	Lachesis	175	0.09	897	C	0.131	71	208888	-3014296		0.07	136	13	0.4	S				17 29.1	-30 15
Sep 1	165	Loreley	228	0.09	1470	C	0.254	92	59132	+30 1240		0.06	147	5	0.4	SA	N30 689	0.57	-0.4	6 27.6	30 18
Sep 11	51	Nemausa	156	0.14	633	CU	0.263	232	146780	-02 5986		0.34	376	31	1.5	PZ		0.03	0.1	23 33.3	-1 20
Sep 12		Neptune	50184	2.30	*****		0.003	111		KMN 31		0.02	516	223	0.5	H				17 44.7	-22 11
Sep 13	94	Aurora	191	0.07	1161	C	0.253	102	183331	-2411965		0.06	165	6	0.4	X				15 15.7	-24 58
Sep 14	259	Aletheia	103	0.04	471	CMEU	0.172	85	77803	+20 1199		0.24	608	33	1.6	ZA	N20 604	0.21	-0.6	5 57.9	20 41
Oct 1	120	Lachesis	175	0.08	902	C	0.243	81	185970	-2914221	A	0.07	144	6	0.4	X				17 55.6	-29 03
Oct 5	372	Palma	196	0.15	956	CEU	0.245	269		+26 4701		0.07	85	6	0.3	A	N27 2798			23 49.8	27 35
Oct 8	10	Hygiea	443	0.18	3318	C	0.402	103	183401	-19 4084		1.15	2897	69	7.9	G				15 20.4	-20 20
Oct 9	36	Atalante	124	0.11	345	C	0.378	63	41289	+44 1517		0.10	111	6	0.5	SA	N44 681	0.15	1.1	6 41.9	44 51
Oct 14	55	Pandora	113	0.05	438	CMEU	0.315	107		+20 2365		0.07	161	5	0.5	XA	N20 1125	-0.00	-0.0	9 41.6	20 03
Oct 20	6	Hebe	186	0.11	734	S	0.396	102	161267	-18 4886	K	0.19	326	11	1.1	YZ		0.45	-0.6	18 16.5	-18 28
Oct 23	804	Hispania	175	0.09	745	C	0.383	75	210091	-3412784		1.24	2451	78	7.5	FP		-0.10	-0.4	18 23.1	-34 24
Oct 27	159	Aemilia	141	0.06	733	C	0.168	83	188979	-20 5831		0.64	1547	92	4.3	X				20 09.1	-20 26
Nov 12	52	Europa	291	0.11	1916	C	0.362	109	139084	-00 2640		0.38	1032	25	2.7	XA	S 0 1793	-0.79	0.7	12 58.5	-1 02
Nov 19	532	Herculina	217	0.09	1213	S	0.339	88	187978	-2614068		0.11	266	7	0.7	X				19 18.9	-25 55
Nov 20	6	Hebe	186	0.10	712	S	0.468	92	187870	-20 5459		0.10	195	5	0.6	X				19 13.7	-19 57
Nov 20	313	Chaldaea	108	0.11	333	C	0.185	245	129646	-02 345		0.13	135	17	0.6	SA	S 1 188	0.10	-0.4	2 01.9	-1 42
Nov 24	545	Messalina	105	0.06	411	C	0.080	73	128200	+05 5176		0.41	718	121	2.3	SA	N 5 3383	-2.26	1.0	23 27.6	5 43
Dec 1		Mars	6782	4.93	*****		0.577	113	138836	-00 2587		0.27	374	11	1.4	XA	S 1 1676	0.02	-0.4	12 31.2	-1 41
Dec 5	1467	Mashona	115	0.06	562	C	0.187	243		+49 1016						A	N50 390			3 44.9	50 13
Dec 10	173	Ino	169	0.08	863	C	0.157	97		+05 2460		0.06	133	10	0.4	XA	N 5 1601	-0.00	0.1	11 12.0	5 03
Dec 25	62	Erato	113	0.05	504	C	0.101	106	118937	+04 2498		0.08	161	18	0.5	XA	N 4 1526	-0.05	0.3	11 35.0	4 02
Dec 25	140	Siwa	105	0.07	434	C	0.214	270		+21 812		0.04	57	4	0.2	XA	N21 504	0.01	0.0	5 17.4	21 16
Dec 26	27	Euterpe	116	0.10	332	S	0.231	109		+05 2507		0.09	110	10	0.4	XA	N 4 1521	0.00	-0.0	11 32.0	4 42
Dec 30	4	Vesta	555	0.47	4326	U	0.224	278		+18 775		0.05	63	6	0.3	XA	N19 418	0.00	0.0	5 03.2	19 04
Dec 30	91	Aegina	106	0.10	326	C	0.145	257	76615	+24 658		0.06	58	9	0.2	XA	N24 408	0.39	-0.7	4 25.6	25 02

Explanation of Data in the Second Table. The date, occulting object's name, and the star's SAO number are repeated for identification. The minor planet's number, the expected diameter in km, and the apparent angular diameter in arc seconds, are given. Under RSOI, "Radius of Sphere of Influence," the distance in km from the object is given where the gravitational attraction of the object is equal to that of the sun, assuming (pessimistically) that the mean density of the asteroid 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 occultations actually have been seen 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. After RSOI, the taxonomic TYPE is given for asteroids, as specified in the Tucson Revised Index of Asteroid Data (TRIAD) as published in pages 783-806 of the book *Asteroids* (see *O.N. 2* (9), 104) and recently updated by Tedesco. The types are determined mainly from observations of albedo (reflectance) and spectral characteristics (color), and are named from meteorites with similar properties. Hence, specific mineralogies are implied, which may not be completely correct. However, most asteroids of a given type probably do have similar compositions. The nine types are described below:

C low albedo, carbonaceous
S moderate albedo, silicate
D low albedo, dark
F low albedo, flat spectrum
M moderate albedo, metallic
P pseudo-M, low albedo, spectra like M
E high albedo, enstatite achondrites
R moderate to high albedo, red (iron silicates)
U unclassifiable in the other categories above

Composite types, such as "CMEU," only mean that the observations exclude the other types, but in such cases, "M" really means "M or P," and some asteroids currently classified M may be P. The first value under MOTION is the geocentric angular velocity of the occulting object in degrees/day. Multiply the listed numbers by 2.5 to obtain the angular rate in seconds of arc per minute, which is useful for estimating when the asteroid's and the 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 PA.

The star's B.D. or C.D. number is given under the DM NO. column. For declination zones north of -22°, the number is a B.D. number, while to the south, it is C.D. The -22° zone can be either, although the B.D. number is then usually used. C.D. numbers in the -22° zone are about twice as large as the corresponding B.D. number for the same star, or for stars with similar right ascensions. The star's double star code is given under D. 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 the U. S. Naval Observatory. More information about this code is given in *O.N. 2* (1), 3, and will be repeated in the first "New Double Stars" article in this volume.

The star's angular diameter is expressed in four ways: In milliseconds of arc (0".001); in meters subtended at the occulting object's geocentric distance; the geometric (ignoring diffraction) TIME in milliseconds for the occulting object's limb to cover the star's disk in case of a central occultation, and in terms of diffraction fringe separation (df). For values of df from 0.1 to 3, the diffraction pattern will be modified enough that the stellar diameter could be computed from an analysis of a good-quality high-speed photoelectric record. If df is less than 0.1, the diffraction pattern will be modified so slightly by the star's diameter that a determination likely will not be possible with even a good-quality record. For values of df greater than 3, the fade will be entirely due to the star's diameter, and diffraction will not be evident, which means that the local slope on the occulting object can not be determined unless very accurate times are obtained at two stations separated by approximately the star's diameter in meters as subtended at the occulting object's geocentric distance, in a direction perpendicular to the motion of the occultation shadow on the ground. The stellar angular diameter is computed from the Warner formula (given in *Mon. Not. Royal Astron. Soc. 158*, 1P, 1972) using B and V magnitudes for the stars from SKYMAP. For stars not in SKYMAP, the catalog photovisual magnitudes have been assumed equal to V-mags., while B-V values have been inferred from the spectral types. If the latter are not available, the star's angular diameter can not be estimated, and the columns are left blank.

The source used for the star's position and proper motion is given under S, according to the following codes: A, AGK3; F, FK4; G, Albany General Catalog (G.C., via SAO; positional data old and usually very poor; G.C. data are used in the SAO for most stars of 6th and 7th mag.); H, positions of faint stars derived by A. Klemola from astrographic plates taken at Lick Observatory, Mt. Hamilton, CA; L, positions determined from plates taken at Lowell Observatory; P, Perth 70; R, positions determined from plates taken at the Royal Greenwich Observatory; S, SAO; X, USNO XZ-catalog for stars within 6° 40' of the ecliptic, the limit for earth-based lunar occultations (with some exceptions; see *O.N. 2* (6), 60; stars with code X south of declination -3° use SAO data, but are indicated here for possible double star codes derived from lunar occultations or spectroscopy); Y, Yale (for stars south of decl. -3°, Yale data are better than Z.C. or G.C.; Wayne Warren, Greenbelt, MD, provided these data); and Z, Zodiacal Catalog (Z.C.; but positional data improved with other catalog data for stars north of declination -4°; the Z.C. is a subset of the brighter stars of the XZ, but with some positional information independent of SAO for the southern stars). The following codes are not in the current list, but may be used in the future: C, Carte du Ciel (Astrographic Catalog); K, USNO K-catalog (Yale stars with no proper motions available); N, N30; and 3, FK3 or AGK3R. If there are two letters under S, the second one is the position and proper motion source for the comparison shift data following the AGK3 number. AGK3 positions are often better than SAO positions, but are generally inferior to XZ and Perth 70 positions. The path shift, in the (occultation path) sense, second catalog minus first catalog, is given under Shift, which is expressed in seconds of arc, to the north if positive and to the south if negative. For instance, -1.00 would mean that the path would be at the southern edge of the possible area described in the first table, according to the second star catalog. The value in minutes to be added to the U.T. is given under Time. The last two columns give the star's apparent R.A. and Dec. computed for the time of geocentric conjunction, for direct use with setting circles. See *O.N. 2* (10), 120 for the 1981 positions of 21 bright stars, which will be accurate enough to use with the 1983 positions in the Second Table.

Ephemerides. About half of the asteroidal ephemerides I use are computed from osculating orbital elements computed by Herget, as mentioned above. Since osculating orbital elements now are published to full precision by I.T.A. in their annual *Ephemerides of Minor Planets*, it is possible to compute ephemerides using their data and compare them with Herget's ephemeris data at the times of predicted occultations and at the times of astrometric observations published in the M.P.C.'s. The latter comparisons show that, when the ephemeris differences are significant, the Herget elements usually are the better, giving smaller observational residuals, but since many of Herget's elements are now over five years old, some of the new orbits computed by I.T.A. utilize more recent observations and are better than Herget's data. Examples include (334) Chicago and (712) Boliviana, although the observational differences are small in these cases. The orbital elements given by Herget in the 1981 August M.P.C.'s have been adopted by the I.T.A. and used in EMP for 1983. The differences in the occultation predictions, where I have ephemerides computed from two different sources, are given in Table 3.

Table 3.

Ephemeris Differences for 1983

Date	MP#	Shift	Δt	EPHEM. SOURCE
Jan 19	59	1″.29S	$-11^{m}.1$	EMP 1979
Feb 5	45	0.08N	0.8	EMP 1982
Feb 14	114	0.74S	-1.1	EMP 1982
Feb 21	59	1.19S	-4.6	EMP 1979
Mar 2	426	3.96W	3.7	EMP 1981
Mar 6	92	0.24S	-0.8	EMP 1975
Mar 7	536	0.60N	-18.6	EMP 1982
Mar 8	334	0.50S	-9.6	HERGET78
Mar 17	1172	0.13S	3.1	ITAB 148
Mar 29	747	0.06N	0.7	EMP 1982
Apr 4	804	6.80S	-0.1	EMP 1982
Apr 7	532	0.24S	-0.8	EMP 1981
Apr 12	164	0.60N	4.2	EMP 1981
Apr 21	71	0.52S	-0.4	EMP 1982
Apr 28	83	0.32N	-3.3	EMP 1980
May 6	71	0.47S	-0.2	EMP 1982
May 24	18	0.12S	1.5	EMP 1980
Jun 15	83	0.50S	2.1	EMP 1980
Jul 13	356	0.02S	-1.4	EMP 1977
Jul 23	45	0.59N	-3.0	EMP 1982
Jul 23	185	0.25S	0.5	EMP 1982
Aug 3	40	1.2S	9.3	EMP 1975
Aug 5	747	0.47N	-1.5	EMP 1982
Aug 6	45	0.76N	-3.5	EMP 1982
Aug 13	712	1.79S	-4.1	HERGET78
Aug 21	372	0.97S	0.3	EMP 1982
Sep 11	51	1.15S	3.3	EMP 1981
Sep 14	259	3.31N	21.9	EMP 1982
Oct 5	372	0.84S	-1.4	EMP 1982
Oct 9	36	0.45N	0.6	EMP 1980
Oct 14	55	0.27S	0.6	EMP 1981
Oct 23	804	2.87S	3.2	EMP 1982
Nov 12	52	0.11S	0.0	EMP 1975
Nov 19	532	0.00N	-0.3	EMP 1981
Nov 20	313	0.06S	1.2	ITA 1977
Dec 25	140	0.11S	-1.5	EMP 1982

The value in the shift column gives the path differences in arc seconds measured perpendicular to the asteroid's geocentric motion; the letter following it tells which direction the occultation path will be displaced on the earth's surface from the nominal prediction given in the first table. The value in the Δt column tells whether the geocentric time of closest approach will be early (negative) or late (positive) in minutes relative to the nominal prediction. The EPHEMeris SOURCE is given in the last column; the shifts are in the same sense of the source specified in this column minus the nominal source listed in the first table. Many of the differences are quite small so that comparison with even relatively recent observations in the M.P.C.'s yield only insignificant differences in the residuals. In these cases, my predictions usually agree well with those by Taylor and Wasserman *et al.*, except sometimes when different stellar data are used; they usually use AGK3 data, while I use data from other catalogs, when available. Recent M.P.C. observations clearly favor my nominal ephemerides for (259) Aletheia and (804) Hispania. This is also the case for (216) Kleopatra, (247) Eukrate, and (776) Berbericia. Taylor predicts occultations by these last three asteroids on April 17, Sept. 8, and Dec. 28, respectively, but the Herget ephemerides, which agree with modern observations, show that the occultations definitely will not be visible from the earth. The orbital elements for (776) Berbericia given in EMP 1982 are in good agreement with Herget's elements only in late 1983, both showing that no occultation will occur on Dec. 28, the geocentric separation exceeding 12". However, both Taylor and Wasserman *et al.* used elements from EMP 1980 and found the occultation; I confirm their calculations if I use the EMP 1980 elements. The I.T.A. failed to mention in either EMP 1981 or EMP 1982 that they had changed the elements for Berbericia, although the EMP 1980 and EMP 1982 elements give very different residuals for observations made in 1977, 1980, and 1981 published in the M.P.C.'s. Curiously, those residuals are considerably smaller for the EMP 1980 elements than for the ones in EMP 1982. I find that occultations of 9th-mag. southern SAO stars predicted by Taylor for (117) Lomia on Apr. 28 and by Wasserman for (120) Lachesis on May 18 will be visible from Antarctica at best, so I have omitted them, also. With the exception of the occultation on April 4, I find that the occultations by (804) Hispania predicted by Wasserman *et al.* will not occur. Since I find this to be the case with all available orbital elements of (804), an error in entering the orbital elements at Lowell probably was made. They consequently missed discovering the occultation of 1.9-mag. ε Sagittarii on Oct. 23.

Herget's ephemeris indicates that the occultation by (426) Hippo on March 6 will miss the earth's surface to the east, but the event occurs near a stationary point in R.A., and the differences from the EMP orbit are not significant at other points on the orbit. Since astrometric observations for most of these relatively high-numbered asteroids are made near opposition and not near the stationary points, recent observations published in the M.P.C.'s can not yet distinguish which is the better orbit. Astrometry of (426) in early 1983 can establish whether an occultation will in fact occur. In general, astrometry of asteroids considered for occultations is needed near the stationary points as well as near opposition. I suggested this for guidelines for astrometric observers of asteroids which were outlined in the meetings of Commission 20 of the I.A.U. during the General Assembly in Patras, Greece, in August. These guidelines probably will be published first in the M.P.C.'s I supplied a list of 263 asteroids, including 248 with diameters of 100 km or larger; 14 smaller than 100 km but subtending more than 0″.12 at favorable oppositions; and the unusual object (44) Nysa.

Maps and Finder Charts. A map showing my predicted paths of asteroidal occultations during 1983 in the U.S.A., southern Canada, and northern Mexico will be published in the 1983 January issue of *Sky and Telescope*. Maps for individual events to be published in future issues of *O.N.* are described below; some of these for late 1982 events are in this issue. The wide area chart of the finder charts usually is based on the *Atlas Coeli*, showing stars to 7th mag., so that it corresponds approximately to the view in many finder scopes. Perhaps only one bright star, labeled on the sky maps published monthly in *Sky and Telescope*, is shown; presumably these charts or others at least as detailed, are available to all *O.N.* readers. The wide-field chart sometimes is not included for very familiar regions when two or more stars on the *Sky and Telescope* monthly map are on the detailed map. The detailed map is usually 4° on a side and is based on SAO data (complete to about 9th mag.) for stars south of -2° declination and on AGK3 data (complete to about 10th mag.) for stars north of -2°. The path of the asteroid is shown, with 0^h U.T. tick marks for four dates starting with the date two days before the date of the event. Hence, there will be three tick marks on the side of the occulted star before the event, and one mark after. Close double stars are underlined. For stars fainter than 8th magnitude, I have compared the detailed charts with Papadopoulos' *True Visual Magnitude Star Atlas* to add some 11th and even 12th mag. stars in the vicinity of the star to be occulted. This comparison also serves as a final check of the chart against a very close equivalent of the visual appearance of the actual sky. Finder charts are published in *O.N.* for events potentially visible from North America and Europe. Others usually are distributed to observers or to national coordinators who further distribute the charts, which are usually only the detailed computer-produced charts.

The computer-produced charts need to be compared with detailed charts such as *Atlas Eclipticalis* to identify numbered and lettered stars, add variable stars, and check catalog errors (especially the AGK3 omits some very bright stars and information about duplicity). Volunteers with access to the necessary catalogs are sought to make good drawings of the finder charts suitable for publishing in *O.N.* You are especially sought for this work if you have access to the *True Visual Magnitude Star Atlas*, but since this is not the case for most *O.N.* subscribers, it is not a prerequisite.

World Maps. Mitsuru Sôma, Tokyo, Japan, produces the world maps published in *O.N.* by computer, using stellar and ephemeris input data supplied by me in machine-readable form. For asteroids and satellites, the three closely spaced parallel lines show the predicted central occultation line, and the northern and southern limits, with U.T. marked at one-minute intervals and labeled at five-minute or ten-minute intervals along the central path. For major planets, the limits are not near the central line, and usually only one limit will be shown. Sometimes, no limit will be shown, but only a parallel line, or lines, labeled with the distance in arc seconds from the center of the planet. This is often the case for Uranus and Neptune, when only occultations by possible rings are predicted. The two parallel dashed lines show the central occultation path in case the minor planet passes 1".0 north or south (measured perpendicularly to its path in the sky) of its predicted path with respect to the star. Combined ephemeris and star position errors can cause path shifts this large or larger. Other parallel lines are sometimes drawn and labeled by hand to indicate alternative predictions based on ephemerides or star positions other than the ones I used. The sunrise and/or sunset terminator is shown, with hatches indicating the side of nighttime visibility. The star and occulting object are in the zenith for an observer at a site indicated by the center of the circular projection of the earth; the objects are on the horizon for sites at the edge of the circle. The altitude above the horizon can be estimated for any site shown on the map; the cosine of the altitude is the distance of the site from the center of the circle divided by the radius of the circle. The sun altitude can be estimated by the distance from the terminator. World maps for 1983 will appear in future issues, but some for events late in 1982 are in this issue.

Regional Maps. The more detailed regional maps are prepared with a computer program originally written by Fred Espenak at Goddard Space Flight Center, and extensively modified by me. The parallel curves represent the path of the center of the occultation shadow, considering several different shifts of the occulting object from its predicted path with respect to the star. The nominal path is labeled "0" and is drawn slightly heavier than the other paths. The parallel curves show the central path for multiples of 0".1 shifts of the asteroid from its predicted path in the sky, measured perpendicularly to the path. Curves are labeled in the map margins with "N" or "S" showing shift direction; "E" or "W" are used if the occulting object's motion is nearly due north-south. Dashed curves show predicted U.T. of central occultation, or of closest approach. Low star altitude or twilight boundaries are drawn when appropriate. A stippled line marks the moonrise or moonset line, if either is present. The expected diameter of the occulting object, in km and in arc seconds, is given in the heading. The ephemeris source is indicated below the map; the stellar data used are indicated by the first entry under the "S" column of the second table. Dashed curves parallel to the solid curves indicate predictions for the path center based on other stellar and/or ephemeris data, as labeled. Asterisks show the locations of observatories from which photoelectric occultation observations have been attempted in the past, as far as I know. The regional maps are "false" projections, plotted with a constant linear scale (constant degrees per centimeter) in both longitude and latitude, so that the reader could, for example, plot updated computed path points which might be provided by Gordon Taylor or by Lowell Observatory. Updated predictions by me usually are given as a path shift in arc seconds, which can be interpolated between the adjacent solid curves on the regional map, and a correction to the time, either earlier or later than the time estimated for a given location from the map by interpolating between the dashed U.T. curves. If the correction to the time is very large, the continents will be shifted in longitude relative to the occultation curves due to the rotation of the earth, and the path shifts consequently will be slightly different along curved paths. This effect is greatest for paths extending nearly due north-south, and is inconsequential for east-west paths. I take this effect into account when I derive an updated path shift value, using a average value for a given regional map since the error in doing this is almost always less than the uncertainty of the astrometric update. Regional maps usually will be published in *O.N.* only for occultations potentially observable from Europe or North America. Regional maps for other areas with at least a few IOTA members are distributed either directly to them, or to national coordinators for further distribution. Regional maps for 1983 will appear in future issues, but four for late 1982 are in this issue.

Local Circumstances. Predictions of local circumstances of planetary occultations and appulses, which supplement the tables of general data given in *O.N.*, are computed and distributed to all IOTA members by Joseph E. Carroll, 4216 Queen's Way, Minnetonka, MN 55343, U.S.A., telephone 612, 938-4028. These predictions are available to non-IOTA members by sending Mr. Carroll accurate geographical coordinates and $1.00, payable to I.O.T.A.; processing of requests will be speeded up by supplying a S.A.S.E.

Observational Methods. Numerous techniques and hints for observing planetary occultations have been discussed in previous articles on predicted and observed events in *O.N.* and in *Sky and Telescope*, especially in my annual article in the January issue of the latter. Some of the more important methods and considerations are described below.

Use the telescope with the largest aperture available, to give the brightest-possible image of the target star. Also, with a larger aperture, you are more likely to see the asteroid approaching the star, 30 to 10 minutes (depending on the motion) before the time of closest approach; this will give confidence that the correct star has been identified. With a larger aperture, there will be a higher signal-to-noise ratio, so that an occultation will be more clearly visible. If the asteroid is not visible, and the star appears faint, dimmings due to atmospheric seeing variations are likely to be mistaken for occultation events. Since separations of only a few thousandths of an arc second often can be resolved during an asteroidal occultation, very close double stars sometimes are discovered. The ability to see immersions and emersions occur in steps due to duplicity is better if the star appears brighter.

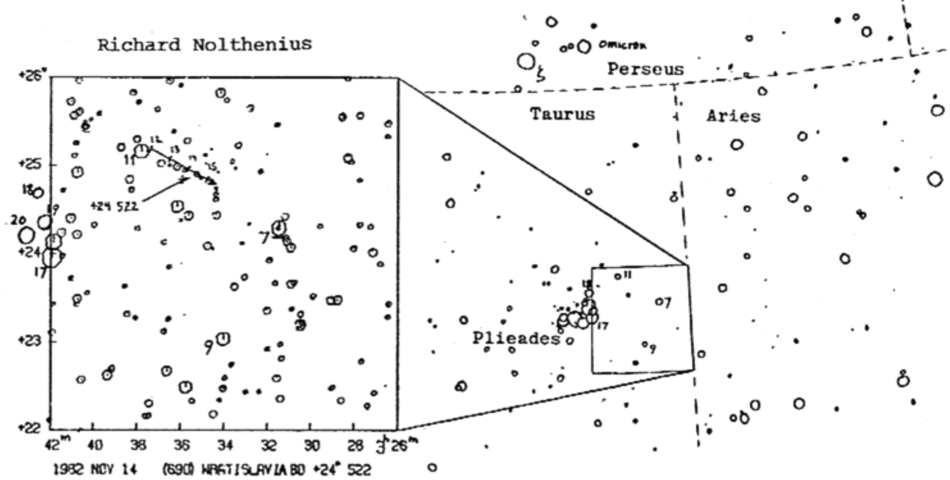
The value of practice in locating the target star before the night of the occultation can not be overemphasized. A good finder scope, able to see stars to about 8th mag. and with at least a 5° field of view, is highly recommended. On your first try, allow at least 30 minutes to find a star in a difficult field, such as one more than 2° from a 3rd-mag. star, especially if strong moonlight is present. After a little practice, you will be able to locate the target star quickly, an ability which may be important during the night of the event, especially for those travelling relatively great distances with portable equipment. If your telescope is equatorially mounted and has setting circles, practice using them to offset from a nearby bright star to the target star.

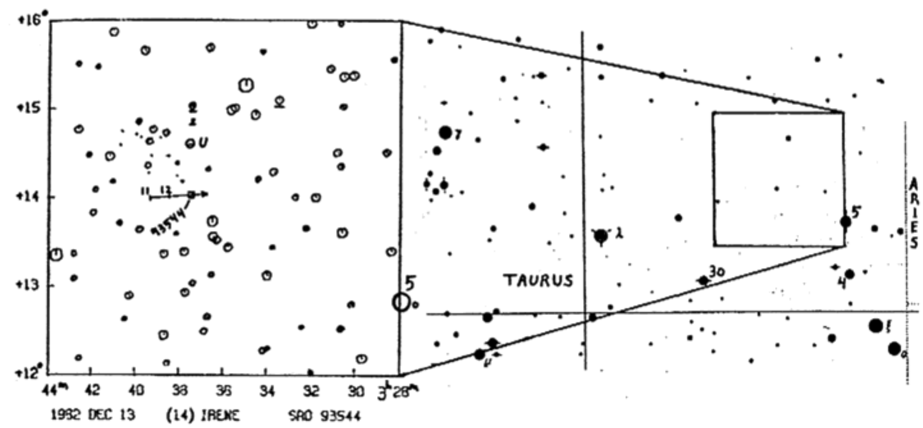
The best current method of recording an occultation is with a high-speed photoelectric photometer. Although this has been almost exclusively the domain of professional astronomers at major observatories, designs and components for relatively inexpensive photometric systems have been, or are being, assembled at the University of Texas and at Lowell Observatory. News of these systems will be announced in *O.N.* as they become available; eventually, it is hoped that at least one of the systems will be marketed commercially in completely assembled (or nearly so) form. Other automatic recording methods include video and photography. Paul Maley has photographed breaks in star trails during occultations of relatively bright stars with an unguided 9-cm aperture telescope.

The best way to record a visual observation is to tape record event marks and comments along with short-wave radio time signals. This is better than using a stopwatch since the record can be replayed several times, to refine the time of marked events; multiple events in quick succession can be recorded; and remarks about observing conditions and interruptions can be included in the timed record. Events can be marked either by voice or (perhaps preferably, since hand reactions may be quicker than voice) by a mechanical clicker or electronic tone generator, such as a door bell. Mechanical crickets marked "IOTA" can be used and are still available from Victor Slabinski, 3457 S. Utah St., Arlington, Virginia 22206, by sending him 20 cents (can be a postage stamp) and a S.A.S.E. Valuable practice can be gained by timing some lunar occultations; see my "Occultation Highlights" articles in each January's issue of *Sky and Telescope* if you currently do not have predictions for your location. Field experience gained from timing multiple events during a lunar grazing occultation can be especially useful for observing asteroidal occultations with portable equipment.

Single observations of asteroidal occultations provide a very accurate astrometric measurement of the asteroid relative to the star, but tell us little about the occulting object. Asteroidal occultations are best observed as a group or regional project; at least two, and preferably three or more, well-distributed chords (ideally, one near the center and one near each of the limits) are needed in order to determine the asteroid's mean diameter reliably. Consequently, when last-minute astrometry shows that an occultation might be visible from your region, as many observers as possible in cities and towns throughout the region should be notified. Gall's *Astronomical Directory* and the *International Directory of Amateur Astronomical Societies* are both arranged geographically and, along with some directories of national professional societies, are useful for contacting potential observers. For events visible from North America, finder charts often are published in *Sky and Telescope*, to which non-*O.N.* subscribers can be referred. But most important, observers with portable equipment are needed to travel to locations between cities with observers, to fill gaps in the coverage and increase the chances of obtaining enough well-distributed chords. The deployment is a little like that for a lunar grazing occultation, but on a much larger scale. The observing "fence" is much longer, to cover both the asteroid's diameter and the prediction uncertainty; observers generally are separated by tens of kilometers. When possible, visual observers should observe in pairs, separated by a km or more to confirm each other's timings by independent observation not affected by the same local atmospheric seeing cell or cloud. If the motion of the occultation shadow is relatively slow, the observers of a pair might separate themselves along the direction of motion by a distance large enough to produce a time difference of 2 seconds or more; the regional map can be measured to tell how large a distance this would be. This will not only allow confirmation of observed occultations, but also will permit a rough measurement of the motion of the occulting object. This would be valuable for establishing that a secondary occultation was caused by a body which shared the motion of the asteroid. Regional coordinators need to balance the need for a large-enough number of observers across the zone of prediction uncertainty to obtain enough well-distributed chords across the asteroid, with the need for confirmed observations by pairs of observers; the available manpower is always limited. Observers in cities relatively far from the predicted path, who can not travel to it, should observe also, in case of astrometric error or to observe a possible secondary occultation. But in such cases, visual observers always should make an effort to observe in separated pairs, as noted above, for confirmation. A secondary occultation by an asteroidal satellite is possible for anyone who has the star above his horizon at night during the appulse, but the possibility of such an event actually occurring, though always low, increases considerably as one approaches the actual occultation path. Secondary occultations almost never have been reported more than ten diameters away from the asteroid. This fact also can be used to plan the period of observation and recording (be sure you have enough tape). Start observing at least ten times the predicted central duration before the predicted time of closest approach (and add to this the uncertainty of the time of closest approach), and continue for at least as long a period afterward, but be careful not to become too fatigued; try to arrange a comfortable observing position, and take a brief break (note when you do this) if you start to become too tired. Be sure to be especially alert during the three or four minutes bracketing the time of closest approach.

Prediction Updates. The predictions for asteroidal occultations can be improved by astrometric observations to update the ephemeris and the star's position a few months in advance. The improvement can be quite good if the asteroid happens to pass near the star, perhaps during its retrograde loop, so that both objects can be photographed on the same plate. Sometimes these preliminary prediction improvements are published in *O.N.* or in *Sky and Telescope*, or distributed by mail by Gordon Taylor, or by Lowell Observatory astronomers, or by me. However, a very accurate prediction generally can not be made until the objects are close enough together to photograph on the same astrographic plate during their final approach, only a few days before the event. In these cases, those of us involved with computing the final predictions must concentrate on notifying those near the path; this is facilitated if those we contact telephone other observers in their areas.





You can find out the latest predicted shift and time correction for upcoming asteroidal occultations by telephoning Astro-Alert in Chicago, IL, area code 312, 259-2376, or Gordon Taylor at the Royal Greenwich Observatory, England, city code 0323, 833171, ext. 3252. Also, information usually can be obtained from Paul Maley in Houston, TX, 713, 488-6871 and, at least for events in the western U.S.A., from Lowell Observatory, Flagstaff, AZ, 602, 774-3358. For some very important events in North America, arrangements will be made to broadcast prediction updates on WWV at hourly intervals during the few days before the occultation.

Notes about Individual Events

Jan. 19, (59) Elpis: On 1977 June 23, J. Ferreira, Fremont, CA, visually reported a "slow fade, some doubt" during a lunar occultation of SAO 118599, reported in *O.N. 1* (13), 140. The observation indicates possible duplicity, with components of approximately equal brightness and separation of the order of 0".04 projected in the 177° p.a. of the event.

Feb. 14: The star is Z.C. 970.

Feb. 28: SAO 162050 = Z.C. 2764 is probably a close double star, based on reports of gradual events observed during lunar occultations, according to G. M.

Appleby, *J. Brit. Astron. Assoc. 90* (6), 572, 1980.

Mar. 2: See 2nd paragraph of the section on ephemerides above.

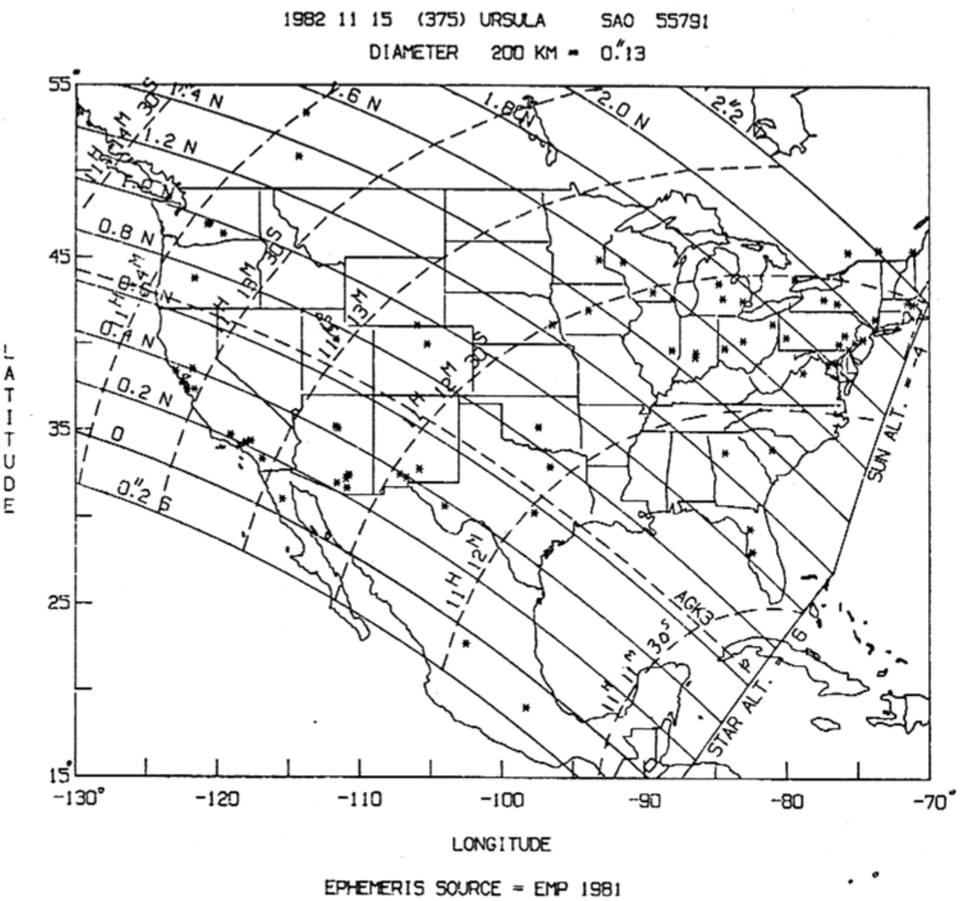
Mar. 3: The star is not in the C.D. catalog. The number given in the DM NO. column is the star's number in the Hyderabad zone of the Astrographic Catalog. Observations of the occultation by the Uranian rings will be needed to locate the star precisely relative to the center of Uranus, which will be needed to make a reasonably accurate prediction for the March 25th events.

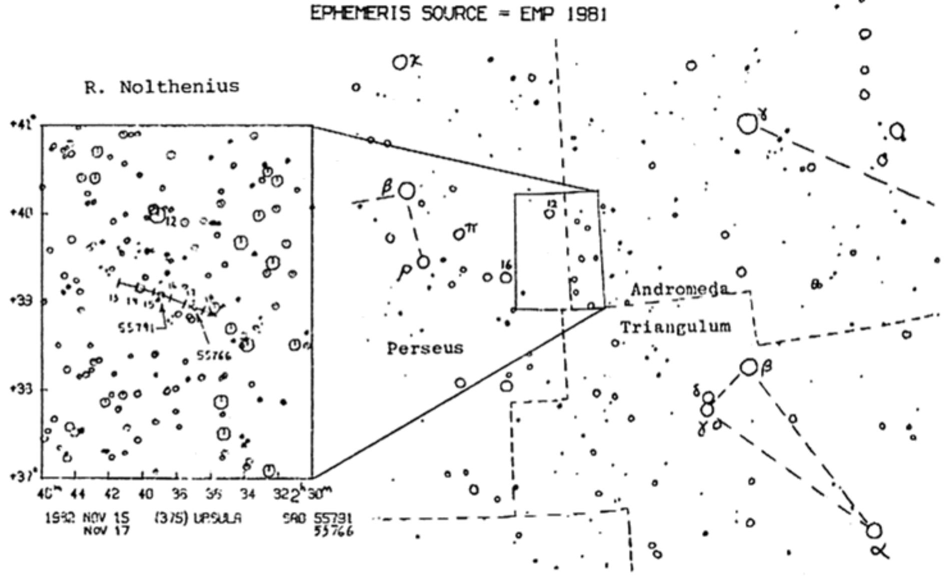
Mar. 8: The star is Z.C. 2611.

Mar. 25: Same star as occulted on Mar. 3; see note above. The prediction for the path of the occultation by Uranus' satellite Umbriel is quite uncertain, but it probably can be improved to less than the path width by a combination of observations of the Mar. 3 occultation by the rings and improvement of the orbital elements of Umbriel, by workers at CERGA, Grasse, France, utilizing relatively recent astrometric observations. Recent work has shown that the Uranian satellites are darker, and therefore larger, than expected; see *Sky and Telescope 64* (3), 227. Observations of this rare event will be valuable for planning for the Voyager 2 flyby of Uranus in 1986. Visual timing of the occultation should be possible, since the star will be 19"6 from the center of Uranus in p.a. 93°. A spot filter or occulting bar (even a fat cross-hair) in the eyepiece focal plane could be useful for diminishing the intensity of Uranus. It is recommended that prospective visual observers try to follow the star when Uranus passes close to it on Mar. 3, to assess the difficulty of the observation. We hope that at least one portable photoelectric station can be deployed within the predicted path, and enough visual observers distributed at suitable intervals across the path to ensure that at least two well-placed chords are timed.

Mar. 28: This event by (2) Pallas might serve as a preview for the very favorable May 29 occultation. If the path of an occultation by a satellite of Pallas can be predicted for May 29, it also might be predicted for Mar. 28.

Apr. 7: (532) Herculina probably has a 50-km satellite, based on the observations of a secondary oc-

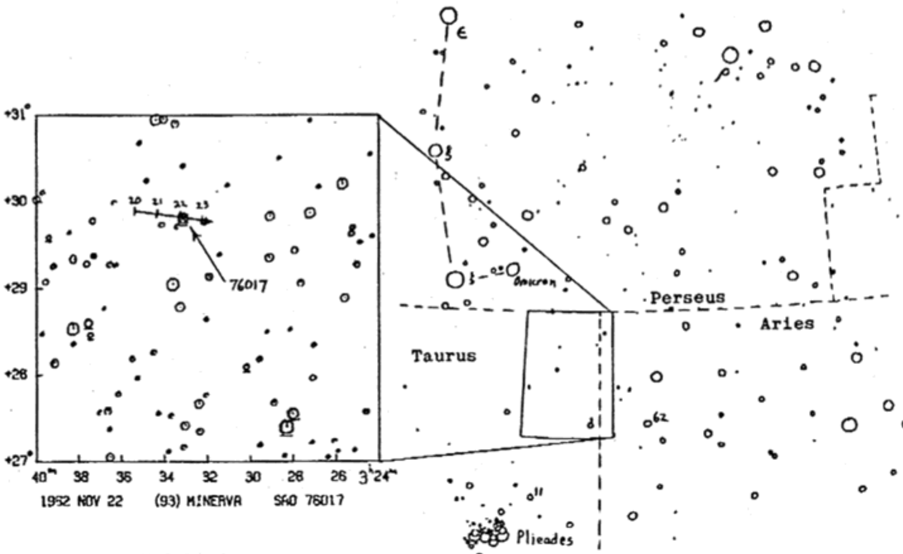




cultation in 1978. There is also evidence for several smaller satellites.

Apr. 12: The inaccuracy of the star position makes the location of this path very uncertain. The XZ simply uses data from the SAO, which in turn uses G.C. information. Astrometry for the 1982 June occultation by (164) Eva also showed a sizeable error in the ephemeris.

Apr. 24: A rather bright moon nearby will interfere somewhat with this event, which probably will be detectible only photoelectrically. In his Bulletin 27, Gordon Taylor writes: "The relative positions of the bodies are such that an occultation is possible by either Pluto or Charon, or both, or neither. The possible area of visibility is the Pacific Ocean, east Asia and Australia (roughly between west longitudes 140° and 250°). Plates will be taken nearer the time to improve these predictions — Pluto passes about 1° south of the star at the end of 1982 November."



Richard Nolthenius

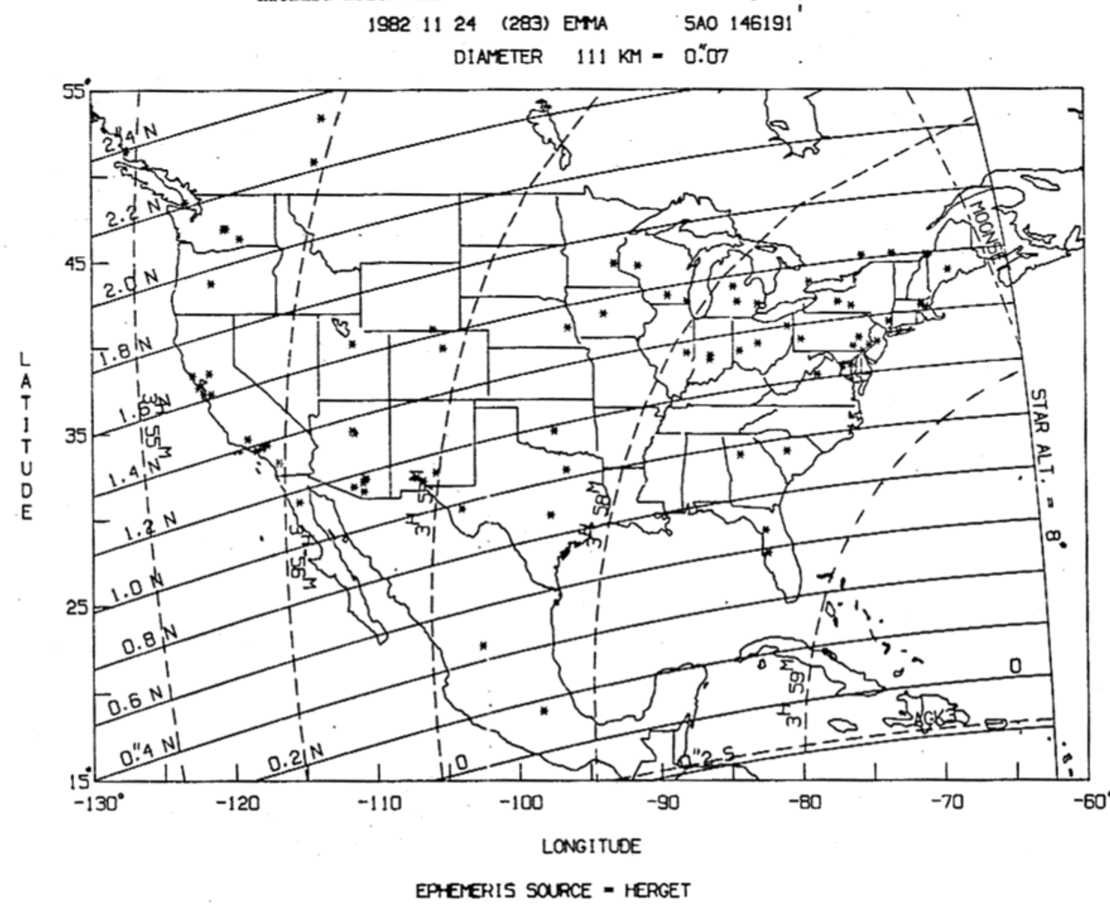
Apr. 28: The star is Z.C. 2727.

May 4: Same note as for Mar. 28.

May 24: (18) Melpomene may have a large satellite, according to observations of the 1979 Dec. 11 occultation; see *O.N. 2* (2), 12.

May 29: More information about this rare event is given in a separate article on p. 2. SAO 87010 = 1 Vulpeculae = ADS 12243. Yerkes spectroscopists report the radial velocity to be variable, indicating possible close duplicity. The faint visual companions (B, mag. 11.8, sep. 39" in p.a. 12°, and C, mag. 13.0, sep. 44" in p.a. 155°, will not be occulted by Pallas.

June 15: The star is not in the C.D. catalog. The number given in the DM NO. column is the star's num-



ber in the Hyderabad zone of the Astrographic Catalog. Since the occultation is nearly central, it may be possible to record a central flash somewhere from the earth's surface. The central path might be predicted based on astrometry a month or two in advance, or when Neptune passes the star during its retrograde motion early in 1983. Four days before this event, there will be a total solar eclipse in Indonesia and New Guinea. Since this occultation will be visible from the same region, some observers already are planning to observe this occultation, which could yield important information about Neptune's atmosphere and the probable ring recently found in 1968 occultation data; see *O.N.* *2* (16), 213. Hans Bode, who is helping to organize a discount trip from Germany to observe the eclipse, plans to record this occultation from Bali. Since the visual Δm will be less than 0.1, the occultation will be detectible only photoelectrically.

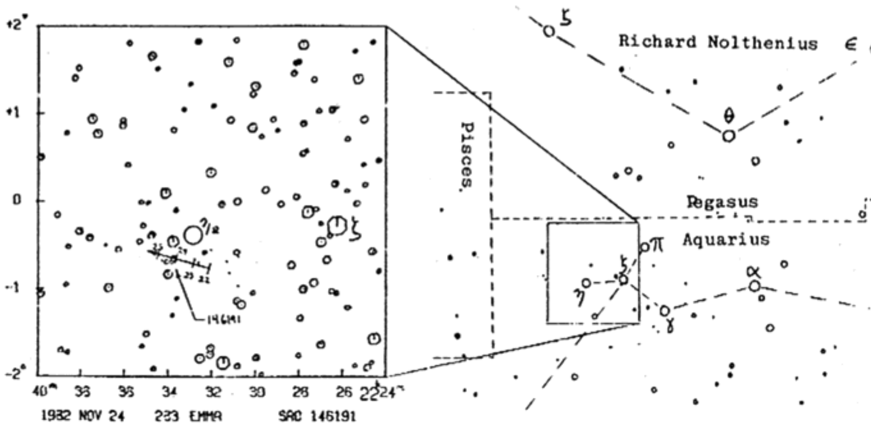
Aug. 21: See the note about asteroid diameters at the end of this article (next column).

Sep. 11: SAO 146780 = Z.C. 3474 = 14 Piscium. The prediction should be unusually accurate, since the star is in the Perth 70 catalog and Leif K. Kristensen, Institute of Physics, University of Aarhus, Aarhus, Denmark, has done extensive work on the orbit of (51) Nemausa to obtain the best-possible orbit referred to the FK4. This asteroid is of special interest dynamically, since its orbit is oriented so that it is always within about 10° of the celestial equator. Hence, good-quality astrometric observations (actual occultation observations are the best possible) of Nemausa are well-suited for determining the location of the equator and the zero point of right ascension. Since 14 Piscium is quite bright and the predicted occultation path is expected to cross populous parts of North America, special efforts will be made to obtain many observations. Like the May 29th occultation by Pallas, it takes place on a Saturday night, facilitating long-distance travel. Nemausa's diameter was determined from observations of an occultation in the southern U.S.S.R. on 1979 Aug. 17, reported by Kristensen in *Astron. and Astrophys. Suppl. Ser. 44*, p. 375 (1981).

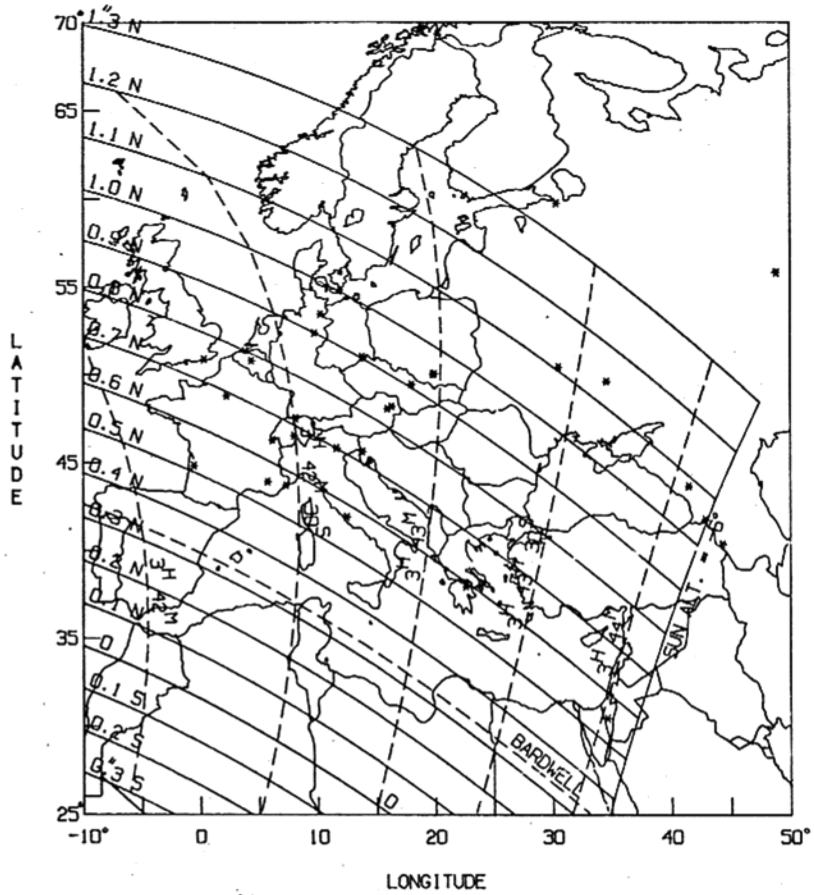
Sep. 14: The star is Z.C. 903. See the note about asteroid diameters at the end of this article.

Oct. 20: The star is Z.C. 2647. The possible duplicity is implied by a visual lunar occultation emersion which was reported as gradual in South Africa on 1923 May 21.

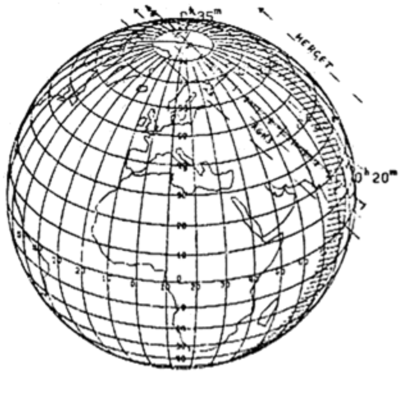
The diameters of (55) Pandora (occulted Oct. 14), (259) Aletheia (Sept. 14), (369) Aepia (Jan. 24), and (372) Palma (Aug. 21 and Oct. 5) are very uncertain due to their ambiguous type. Since a low albedo typical of C-type asteroids has been assumed, the actual diameters for these objects may be considerably smaller, possibly by even more than 50%. The angular diameters and central occultation durations consequently also may be smaller.



1982 12 1 (241) GERMANIA SAO 138236
DIAMETER 187 KM = 0".07

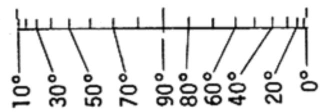


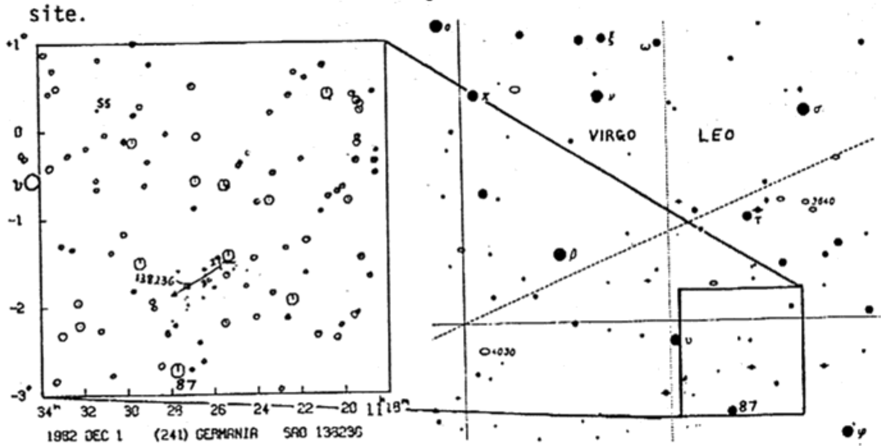
EPHEMERIS SOURCE = EMP 1981



SAO 60144 by Adeona 1982 Dec 22

Use a tracing of this cosine scale to estimate star altitude from the world maps; place the 90° mark at the center of the circle, and read the star altitude at the observing site.

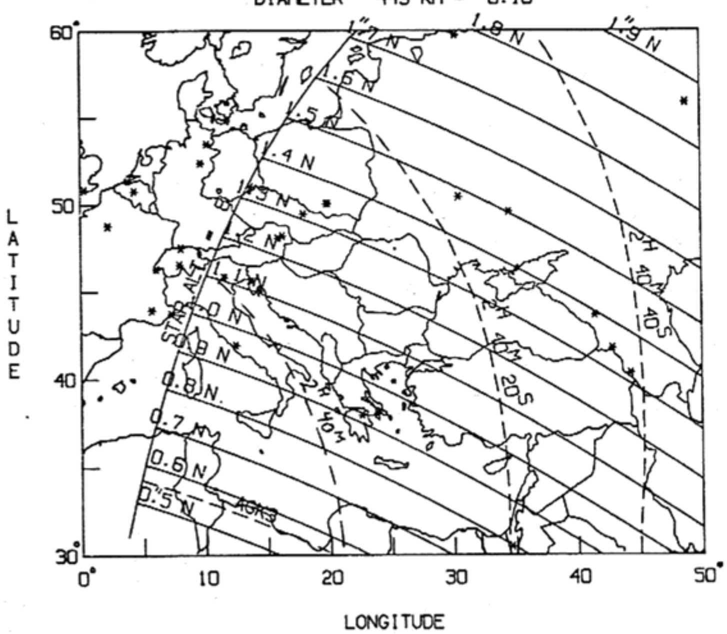


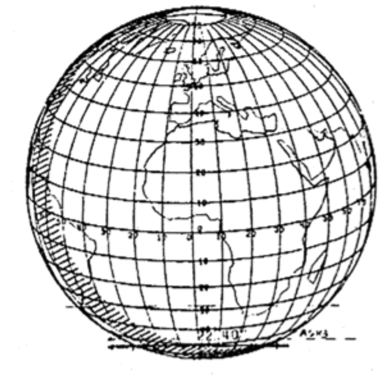


SAO 94638 by Bellona 1982 Dec 27

1982 12 6 (10) HYGIEA SAO 139019

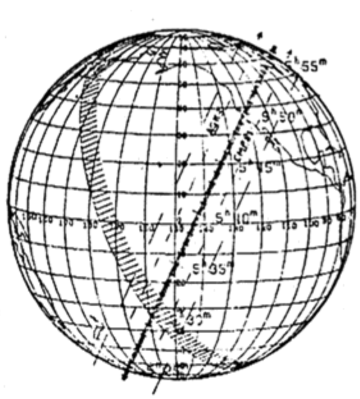
DIAMETER 443 KM = 0."18

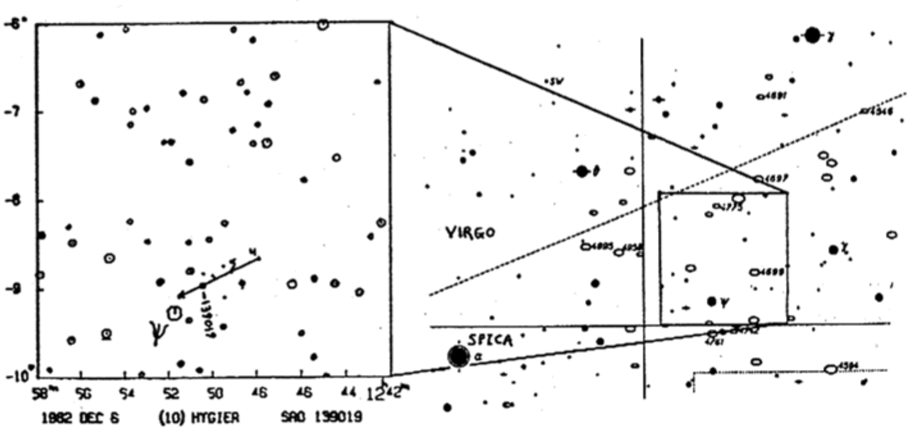




SAO 94582 by Liberatrix '82 Dec 29

EPHEMERIS SOURCE = KLEPCZYNSKI





SAO 110157 by Emita 1982 Dec 21