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POSSIBLE SATELLITE OF (9) METIS PHOTOGRAPHED BY CHINESE ASTRONOMERS

Wang Sichao and David W. Dunham

Elongation of the photographic image of (9) Metis has been detected on plates taken with the Chinese Yunnan Observatory's 1-m f/13 reflector on 1979 Dec. 23; and 1980 Jan. 17, 21, and Feb. 9, 21, and 23; and with the Purple Mountain Observatory's 60-cm f/16.7 reflector on 1980 Jan. 15. The maximum elongation was 1."2 in p.a. 24° - 204°. Observed position angles are consistent with a uniform revolution period of about 4.61 days. The data suggest a possible satellite orbiting Metis with this period at a mean distance of about 1100 km. The other orbital elements are: eccentricity, near 0; p.a. of node, 24°; inclination to plane of sky, 100°; and epoch of ascending node, February 21.59 U.T. The possible satellite is about 2 mag. fainter than Metis. If Metis and the satellite have similar albedoes, the diameter of the satellite would be about 60 km. The observers were Wang Sichao and Wu Yuezhen, Purple Mountain Obs., and Bao Mengxian, Deng Liwu, and Wu Sufang, Yunnan Observatory. One of the images is reproduced in Figure 1.

Fig. 1. The image of Metis on the plate taken on 1980 Feb. 20 at Yunnan Observatory; magnification is approximately [45 times as reduced by the printer]. The possible satellite is the slight bulge (just separated) to the left of the top (north) of the image of the minor planet.

The size and mean distance of this object agree well with the corresponding values (65 km and 911 km) deduced from the secondary occultation timed at Barquisimeto, Venezuela, during Metis' appulse with SAO 80950 on 1979 Dec. 11; see *O.N.* 2 (8) 86 and (9) 103. However, the position angle of the Barquisimeto object does not agree with the above orbital elements. The discrepancy could be removed if the period were 4.d57 and the inclination about 130°; further investigation is being made to see if these values are compatible with the photographic data.

The period and distance of the satellite imply that the mass of Metis is 2.5×10^{-12} Solar mass, or 4.9×10^{21} grams. A lower limit to Metis' diameter, 127 km, is given by Maley's and Nissen's occultation timings at Georgetown, Guyana. An upper limit is given by the value of 168 km given in the TRIAD file in *Asteroids*. This is considered an upper limit since it includes the effects of any satellites, which should be subtracted. The resulting range in density is 2.0 to 4.6 gm/cm^3; a value near the middle of this range would be reasonable.

Hopefully, conclusive confirmation of Metis' satellite will come from possible as-yet unreduced speckle interferometric observations made during the very favorable early 1980 opposition, from observations of this year's occultations of stars on either February 12 or June 14, or from further direct observations of Metis during its opposition three months from now. Metis will not be as close to the Earth (1.67 a.u.) during the 1981 opposition as it was in early 1980 (1.23 a.u.), so the maximum separation should be only 0."9. Also, at declinations near -23°, direct observations from the Southern Hemisphere may be more effective.

FROM THE PUBLISHER

For subscription purposes, this is the first issue of 1981.

O.N.'s price is $1/issue, or $4/year (4 issues) including first class surface mailing, and air mail to Mexico. Back issues also are priced at $1/issue. Please see the masthead for the ordering address.

Air mail shipment of *O.N.* subscriptions currently is $1.80/year extra, outside the U.S.A., Canada, and Mexico, being tied to all-too-frequent changes in postal rates. The last change in overseas rates came on 1981 January 1; it remains to be seen whether or not the change in rates due on 1981 March 22 will affect overseas rates.

IOTA membership, subscription included, is $7/year for residents of North America (including Mexico) and $9/year for others, to cover costs of overseas air mail. European (ordinarily excluding Spain and Portugal) and U. K. observers should join IOTA/ES, sending DM 12.-- to Hans J. Bode, Bartold-Knaust Str. 8, 3000 Hannover 91, German Federal Republic. Spanish, Portuguese, and Latin American occultation observers ordinarily may have free membership in IOTA/LAS, including *Occultation Newsletter en Español*, by contacting Sr. Francisco Diego Q., Ixpantenco 26-bis, Real de los Reyes, Coyoacán, Mexico, D.F., Mexico. Currently, however, the Latin American Section is experiencing problems with funding, and for the time being, it may be necessary for would-be IOTA/LAS members to subscribe to the English-language edition of *O.N.*, or to join the parent IOTA.

(18) Melpomene has an unusually favorable opposition (distance 0.89 a.u.) on 1981 August 22, so speckle interferometry and direct photographic observations have a good chance for revealing the satellite implied by the 1978 Dec. 11 secondary occultation recorded photoelectrically at the Fernbank Science Center in Atlanta, GA. During the few months surrounding the opposition date, the maximum elongations of the Atlanta "satellite" should be at least 1".1, with the 48-km object probably about 2 magnitudes fainter than Melpomene itself. In addition, there are favorable (but difficult for visual observers due to small magnitude drops) occultations of stars by Melpomene on 1981 Aug. 7 and Sept. 4.

D.W.D. sent notice of the Chinese observations, and details about the February 12 occultation by Metis, to about two dozen observers in South Africa and Zimbabwe; M. Soma's world map of the event was published on p. 122 of the last issue. Plates taken at Lick Observatory on February 4 were measured by A. Klemola. Several faint stars along the path were measured, as well as Metis and SAO 184474, the star to be occulted. The observations implied a large north shift, 0".75, putting the path just north of Zimbabwe's northeastern border. W. Warren had the result telexed to the Astronomy Department at Cape University from Goddard Space Flight Center; D. Overbeek also obtained the result by telephoning D.W.D. William Penhallow used 7 of Klemola's secondary reference stars to reduce a plate he obtained a few days before the event. These results confirmed Klemola's result, but with less accuracy due to low altitude and poor seeing. A telegram was sent to an astronomy club in Mauritius, which was a short distance north of the path according to Klemola's data, but unfortunately was received after the event. Skies were clear for several South African observers, who reported no occultation, as expected from the updated prediction. Richard Fleet, Salisbury, reported heavy rain at the time in Zimbabwe.

The Chinese observations of Metis have been submitted for publication in *Icarus*.

IOTA NEWS

David W. Dunham

The Astronomical Division of the Japanese Hydrographic Department now has the responsibility for collecting all lunar occultation timings, as noted on p. 113 of the last issue. Their operation has been designated the International Lunar Occultation Centre (ILOC), since Gordon Taylor at HMNAO remains as the international focus for predictions and observations of occultations of stars by solar system bodies other than the moon. Yoshio Kubo, the acting director of the ILOC, informs me that reports of 1980 occultations written onto HMNAO's forms will be accepted, so if you still have not sent in your 1980 report, send it to ILOC as soon as possible. The new ILOC occultation report forms were sent to several observers early in February. A large supply was sent to USNO, which distributed them to everyone on their active total occultation prediction mailing list. Since the ILOC plans to use USNO's station codes, these should be written on your reports, when known, including reports of 1980 observations. Since ILOC's occultation reduction system is still being designed, there will initially be a considerable delay before residuals are returned to observers. But HMNAO has been unusually slow in returning residuals during the past couple of years, so observers are already accustomed to some delays. In spite of these delays, Dr. Kubo strongly wishes that observers will continue to send their reports to ILOC; the data remain valuable and will be used.

I have made a few additions to the ILOC report forms to produce IOTA/ILOC forms for grazing occultations; see p. 125. Copies of these forms have been sent to all IOTA members and are available from me, or from Tinley Park, upon request. The previous IOTA ("U. of Texas") graze report forms should no longer be used. The ILOC is to be congratulated for solving the problem of making provision on one form for all essential data for both total occultations & grazes.

David Herald reports that, in spite of widespread cloudiness, some observations were made near both limits of the annular eclipse of 1981 February 4 in Tasmania. He noted that, although the 2nd and 3rd contacts were not as sharply defined as for a total eclipse, the Baily bead events during the partial phases close to the annular phase could be timed just as well as the corresponding bead events near the total phase of a total eclipse. Future analysis will show how useful these observations are for monitoring the Solar radius compared to data from total eclipses. Unfortunately, a New Zealand expedition to Stewart Island was completely clouded out.

IOTA member Richard Binzel is to be congratulated for winning the American Physical Society's Apker Award for 1980. This national honor recognizes outstanding achievement in physics by an undergraduate student who demonstrates great potential for future scientific accomplishments. He has obtained photoelectric lightcurves of several asteroids and searched the literature to find early references to binary asteroids. Binzel published these results in *O.N. 1* (15) 152 (1978 July) and was also coauthor with Thomas Van Flandern of the important article on satellites of minor planets in *Science 203*, p. 903 (1979 March). Binzel is now a graduate student at the University of Texas in the Astronomy Department. He timed the occultation by (78) Diana last Sept.

Regional networks and coordinators have been formed for the Asteroid Intercept Radio Net (AIRN), to provide better coverage across North America. The original schedule has been abandoned and Houston Astronomical Society Member Randy Pollard, working with Paul Maley, is the new overall AIRN coordinator, who communicates with the other regional coordinators on the 20-meter band.

A positive leap second will be inserted at the end of June so that the sequence of UTC second markers will be: 1981 June $30^d23^h59^m59^s$, $30^d23^h59^m60^s$, July $1^d00^h00^m00^s$. When USNO's total occultation predictions were computed, it was assumed that this leap second would be inserted just before 1981 Jan. 1, but that was not done. Consequently, 1^s should be added to all of the predicted times in USNO's predictions for the first half of 1981.

The magnitude and spectral type errors in USNO's XZ catalog, described in *O.N. 2* (6) 58-60 and mentioned on p. 114 of the last issue, have now been corrected using my K - XZ matched data read from magnetic tape.

The nodes of the Moon's orbit have regressed enough so that occultations of most J-catalog stars are no longer occurring. A new catalog needs to be created before extended-coverage USNO total occultation predictions can be computed. More coverage of the Milky Way is needed from the Paris zones of the Astrographic Catalog and from IOTA's Southern Astrographic Catalog project, as well as detailed coverage of the Praesepe Cluster. It will take some time to create this catalog, so unfortunately, extended-coverage USNO total occultation predictions for 1981 will be delayed a few months.

Reprints of our *Science* article, "Observations of a Probable Change in the Solar Radius Between 1715 and 1979," described on p. 114 of the last issue, can now be obtained from me; I would appreciate long, self-addressed envelopes or adhesive address labels being sent with requests. Copies will be sent to everyone who took part in the 1976 and 1979 IOTA total Solar eclipse projects. Further information, including the role of grazing occultations, is given in another article, reprints of which are also available, entitled "Determination of variations of the solar radius from solar eclipse observations," by S. Sofia, A. Fiala, and me, published in *Proc. Conf. Ancient Sun* (1980), p. 147-157 (edited by R. Pepin, J. Eddy, and R. Merrill). The authors discuss procedures for predicting the true totality limits (the effects of the Lunar limb are now computed virtually automatically with a non-iterative procedure), address errors affecting the Solar radius determinations, and describe the implications of the results on the constancy of the Solar constant.

Contrary to what was said on p. 114 of the last issue, this issue was delayed in order to give a more complete description of important, timely material. We plan to set a mid-April deadline for material for the next issue, which will probably be distributed about a month later.

GRAZING OCCULTATIONS

David W. Dunham

The table lists successful, or partly successful, expeditions for grazing occultations, reports of which have been received since the list on p. 95 of issue No. 9 (1980 August) was prepared. The format of the list was published in *O.N., 2* (3), 27.

Reports of observations of grazing occultations should be sent to me at P. O. Box 488, Silver Spring, Maryland 20907, U.S.A. If possible, a copy of the report should be sent to the International Lunar Occultation Centre (ILOC), Astronomical Division, Hydrographic Department, Tsukiji-5, Chuo-ku, Tokyo, 104 Japan, and it should be stated on the report whether or not a copy was sent to the ILOC. If no such indication is given, I will send a copy to ILOC. Graze reports should no longer be sent to HMNAO at the Royal Greenwich Observatory, England. Only the new IOTA/ILOC forms (edition of 1981 Feb) should be used for reporting graze observations; use of any of the earlier forms will cause considerable additional delay in the analysis of your data. Copies of the new IOTA/ILOC forms have been sent to all IOTA members, and additional copies can be obtained upon request to me or to IOTA in Tinley Park, IL. If there are four or more successful stations in an expedition, it will be necessary to use two or more forms. If N forms are used, label them at the top, "1 of N", "2 of N", "3 of N", . . . , "N of N", or else, for the additional observers and stations, use letters d, e, f, etc. and D, E, F, etc., writing over the a, b, c, A, B, and C's on the form. The name of the expedition leader and the data at the bottom of the form (both sides) need to be given only on the first form. If positions are determined from more than one map, this should be indicated on the bottom of the front of the forms. Expedition leaders may find it more convenient to give observers copies of the station observation report forms used by IOTA up to now, and transcribe the data from them to the new IOTA/ILOC forms. In any case, the old forms should not be used for final reports sent to either ILOC or to me.

Thomas Van Flandern has provided me with a list of corrections to the positions of many Z.C. and XZ stars based on the latest analyses of all occultation data at USNO. In some cases, there are not enough early observations to determine corrections to the proper motions, but in these cases, only the recent data have been used to determine the corrections to the position. In many cases, the corrections are small and not statistically significant. I will supply you with the shift predicted for a graze for which you plan to lead an expedition with four or more stations, if you send me a self-addressed postcard or envelope and give the date, star number (USNO or Z.C.), and position angle of graze.

Robert Sandy has done a prodigious amount of work preparing reduction profiles for many of the better-observed grazing occultations during the last few years, using reduction data from computer runs which I've made at USNO. Some of his profiles are reproduced in this issue and described in his article. Many of his profiles will not be published, but copies will be sent to the observers, and will be obtainable upon request from others. One or two of the profiles published here were prepared by others, as noted. A couple of other volunteers who can prepare good-quality plots are sought to help Bob Sandy with this important work. Sometime during the next several months, I hope to write programs to automatically prepare Calcomp plots showing most of the features displayed in these graze reduction profiles. Then it should be possible to prepare many plots using the file of over 14,000 timings made during grazing occultations provided to USNO by H.M. N.A.O. about a year ago.

Several of the well-observed grazes during the past few years have been in the "Cassini" regions, the areas beyond (as seen from the Earth) the Lunar north and south poles which could not be mapped by Watts due to poor lighting caused by Cassini's 3rd law. This law, a consequence of orbital dynamics, states that the planes of the Moon's equator, the ecliptic, and the Moon's orbit intersect in a common node, with the ecliptic between the other two. Using reduction profiles for these Cassini grazes, I have considerably expanded the data base of observed graze data used by the ACLPPP profile program, so that the Cassini regions are now rather well-represented on the predicted profiles. This will result in better predictions for grazes in these areas.

There is renewed interest in grazing occultations from the eclipse analyses mentioned in IOTA NEWS. Graze data are needed to refine our knowledge of the polar profiles so that various lunar valleys can be related accurately to each other. With such knowledge, we can accurately link various Baily bead and eclipse contact observations so that more timings can be considered in comparative analyses, such as those for the 1925 and 1979 eclipses. This will result in more accurate determination of solar radius variations. For these reasons, observers are encouraged again to make a special effort for grazes with latitude librations between -1°0 and +1°0, the range in which solar eclipses (and lunar eclipses) occur. For such grazes, as many observers as possible are wanted, to define the structure of the lunar limb in detail.

Mo	Dy	Star Number	Mag	% Snl	CA	Location	# Sta	# Tm	C C	Ap cm	Organizer	St	WA	b
1977														
11	20	3520	6.0	74+	5S	Obihiro, Japan	14	29	7	6	Hidetoshi Yoshida		177	-12
1978														
5	11	1003	7.2	17+	2N	Sapporo, Japan	7	29		6	Hideo Gotô		6	71
9	22	0729	7.2	66-	9N	Sadohara, Japan	2	2	6	25	F. Yamaguchi (ILOC)		348	70
10	21	0934	6.4	71-	10N	Minamata, Japan	3	14	8	25	Fusakichi Ono (ILOC)		351	71
12	20	1549	5.1	68-	5S	Gotemba, Japan	3	7	8	20	T. Takemura (ILOC)		184	20
1979														
1	4	3528	7.5	37+	4S	Obihiro, Japan	5	20	7	6	Hidetoshi Yoshida		181	16
3	5	0692	1.1	47+	-6N	Obihiro, Japan	8	34	7	6	Hidetoshi Yoshida		354	72
5	8	1772	4.0	86+	3N	Nanae, Japan	3	11	8	20	Fusakichi Ono (ILOC)		3	-16
1980														
1	22	0036	7.2	27+	2S	Kurashiki, Japan	1	4	8	20	Minoru Sasaki (ILOC)		180	40
2	21	0405	4.4	34+	1S	Kôchi, Japan	3	5	8	20	Fusakichi Ono (ILOC)		182	67
3	22	0829	7.0	42+	1N	Dresden, G.D.R.	1	2	8	8	Christian Schoebel		359	67
4	18	0669	4.0	12+	3S	Newburg, WI	3	23	8	13	John Phelps	3N	184	70
5	10	3537	6.8	19-	1S	Te Hana,N.Zealand	6	8		20	G. Allcott		181	
5	22	1609	4.7	61+		Pombal, Portugal	2	5		15	Jose Osorio			
5	25	1821	2.9	79+	-4S	Stratford,Ontario	2	12		6	Robert Radko			
5	25	1821	2.9	79+	-4S	Stratford,Ontario	5	22		15	Andreas Gada			
6	18	1487	1.3	27+	N	Grand Cane, LA	5	19	7	9	Paul Goodwin			-4
6	18	1487	1.3	27+	N	New Orleans, LA	14	70	9	20	Robert Schiffer	3N		-4
6	23	2047	6.7	77+	4N	Sakata, Japan	1	4	5	6	Isao Satô		6	-57
7	2	3307	4.9	80-		Lorne, Australia	2	5	1	15	N. Plever			
7	6	0327	4.5	34-	6N	Kaitaia,N.Zealand	2	6	8	6	G. Herdman		353	
7	17	118971	8.1	24+		Gundaroo,Australia	2	8	7	20	David Herald			
7	17	118979	8.5	24+		Jannali,Australia	5	17	6	15	Roger Giller			
7	21	2100	6.6	61+		Birregurra,Austrl.	3	22	9	20	N. Plever			
7	21	2113	7.5	63+		Darkes Frst.,Austl.	1	1	4	20	Roger Giller			
8	5	0667	5.3	29-	N	Collins, MS	3	22	6	25	Ben Hudgens	2N		71
8	5	0692	1.1	28-	-7S	San Antonio, FL	3	14	8	20	Harold Povenmire		170	66
8	6	094604	8.4	19-	7N	Flagstaff, AZ	1	8	7	25	Brian Skiff			
8	6	0884	7.8	17-	7N	Malasiqui,Phil.Is.	1	2		8	Oscar G. de las Alas			
8	8	1175	5.0	4-	-6S	Gapan,Philip.Is.	1	3		8	Oscar G. de las Alas			
8	20	2399	5.0	62+	5N	Soledad, CA	1	5	8	15	Richard Nolthenius		7	-56
8	20	2399	5.0	62+	5N	Greenfield, CA	9	24	7	6	James Van Nuland	5N	7	-57
8	30	110464	7.1	76-	12N	Doswell, VA	3	6	4	13	William Stein		353	39
8	31	0462	5.9	67-	8N	Kitty Hawk, NC	7	40	8	25	David Dunham	0	354	75
8	31	0526	6.9	63-	10N	Sakata, Japan	1	3	3	13	Isao Satô		354	72
9	3	094957	8.5	36-	N	Granollers,Spain	2	2	8	20	Domenec Barbany			
9	5	Venus	-3.9	15-	11N	Up.Bogue,Bahamas	1	4	9	6	Harold Povenmire			
9	17	160558	8.3	47+		Jannali,Australia	3	3	7	15	Roger Giller			
9	19	2814	5.0	68+	N	Bredo, Australia	5	11	7	20	David Herald		7	
9	27	0405	4.4	89-	12N	Bethel, NC	2	4			Floyd Mattheis			
9	30	094814	7.5	60-	10N	Woodworth, WI	1	2	4	13	Robert Hays	0	351	60
10	4	1420	6.6	18-	8N	Patterson, CA	13	34	8	6	James Van Nuland	4N	351	-1
10	5	Venus	-3.7	13-	S	Zuidwolde,Holland	1	2	9	15	Jean Meeus			
10	5	Venus	-3.7	13-	S	Lingen,German F.R.	1	0		6	N. Wieth-Knudsen			
10	5	Venus	-3.7	13-	3S	Zossen,German D.R.	1	8	7	6	Wolfgang Rothe			
10	13	2396	6.6	18+		Talamanca,Spain	3	18	7	20	Carlos Schnabel	5S		
10	30	1259	5.9	53-	9N	Boynton Beach, FL	1	2		15	Harold Povenmire			
11	1	1481	7.4	33-	7N	Creedmoor, NC	1	6	7	15	Robert Melvin	2N	353	-12
11	1	1487	1.3	33-	-5S	Zim, MN	3	17	8	9	David Dunham	0	174	-11
11	1	1529	6.6	31-	4N	Yaita City, Japan	8	31	7	5	Toshio Hirose	4S	355	-18
11	3	1733	5.2	14-	5N	Yorii Town, Japan	4	16	6	6	Kazuyuki Yamada	18S	357	-42

One of the reasons for undertaking the analyses of numerous recent grazes was to provide corrections for a shift from USNO's version 78A to the 80 versions. We thought this would be necessary when the MVT operating system was installed on USNO's computer last August, since we thought that the old 78A version of OCC, Van Flandern's prediction and analysis computer program, could not be used under MVT. However, this turned out not to be the case; we can continue to use 78A. I do not plan to shift to another version until the planned 81 version becomes operational, probably in several months. This will include more detailed empirical corrections, which should result in a significant improvement in the predictions.

Vincent Sempronio, a DC-area observer, has access to a digitizer, similar to a plate-measuring engine, which is attached to a computer. He has programmed the machine to measure grid marks and marks indicating station locations for grazes on a topographic map, then he keys in the coordinates of the grid marks, and the computer calculates and prints the coordinates of all measured stations. Richard Taibi, another local observer, had manually measured the coordinates for a ten-station expedition, and gave the map to Vince to try with the digitizer-computer. He reproduced Taibi's positions to an accuracy of a few tenths of an arc second, which is the expected manual measuring error. We plan to work with Vince to determine the coordinates for several currently unreduced DC-area grazes, to eliminate our backlog. Others who have station coordinates for large expeditions which need to be measured might send me their maps with the station locations carefully marked. Xerox or other photocopies should not be sent, since the copying can distort, and maps should not be folded, at least not in the area which needs to be measured (that is, which contains the grid marks and station locations).

Mo	Dy	Star Number	Mag	% Snl	CA	Location	# Sta	# Tm	C C	Ap cm	Organizer	St	WA	b
11	1	1487	1.3	33-	-5S	Zim, MN	3	17	8	9	David Dunham	0	174	-11
11	1	1529	6.6	31-	4N	Yaita City, Japan	8	31	7	5	Toshio Hirose	4S	355	-18
11	3	1733	5.2	14-	5N	Yorii Town, Japan	4	16	6	6	Kazuyuki Yamada	18S	357	-42
11	3	1733	5.2	14-	5N	Kazu City, Japan	1	2	7	6	Toshio Hirose	18S	357	-42
11	5	139229	7.5	5-		Clinton, MS	2	4	5	20	Ben Hudgens			
11	10	2396	6.6	4+	5N	Westhoff, TX	1	12	5	25	Don Stockbauer	6S	357	-53
11	11	2573	7.3	12+	N	Michelago, Austral.	4	16		20	David Herald			
11	11	2573	7.3	12+	N	Milton, Australia	2	6	8	20	Roger Giller			
11	12	2666	5.0	15+	-1N	San Felipe, TX	1	5	8	25	Don Stockbauer	3N	358	-35
11	12	2666	5.0	15+	-1N	Terry, MS	3	7	1	20	Ben Hudgens		358	-35
11	23	0793	6.2	97-	N	Kambah, Australia	1	2	6	32	David Herald			
12	3	1965	6.5	15-	0N	Vero Beach, FL	1	3		15	Harold Povenmire			
12	4	2072	6.7	9-	-1S	Granite, MD	3	21	7	25	David Dunham	3N	186	-62
12	12	3195	7.7	27+	8S	Hialeah, FL	1	3	8	20	Anthony Dip	4	175	
12	13	164999	8.5	34+	S	Perth, Australia	3	6	7	15	Ian Bacon			
12	15	3492	8.6	50+	4S	Germantown, MD	2	7	5	25	Richard Taibi	0	178	48
12	31	139803	8.6	30-	6S	Jones Creek, TX	1	4	5	25	Don Stockbauer	5S	188	-65
12	31	2035	7.1	30-	8S	Perrine, FL	1	0		15	Harold Povenmire	N		
12	31	2043	6.6	29-	10S	El Campo, TX	1	9	8	15	Don Stockbauer	10S	192	-64
1981														
1	15	0444	6.2	68+	7S	Springfield, VA	1	6	8	16	Robert Bolster	0	171	72
1	15	0444	6.2	68+	7S	Alexandria, VA	3	15		20	Pat Bulman	0	171	72
1	15	0444	6.2	68+	7S	Arlington, VA	1	1		15	Victor Slabinski	0	171	72
1	15	0444	6.2	68+	7S	Bowie, MD	5	27	8	20	Fred Espenak	0	171	72
1	30	2341	7.2	29-	10S	Fleetwood, PA	1	3		15	Craig Patterson	14S		
2	6	146509	7.3	5+	9S	Milton, DE	3	20	7	20	David Dunham	2S	179	41
2	9	109577	7.8	20+	.5S	Spring Lake, FL	1	9	7	20	Thomas Campbell			
2	12	0692	1.1	63+	9S	Delaware, OH	5	27	7	15	Charles Hafey	2S	170	65
2	12	0692	1.1	63+	9S	Streetsboro, OH	4	25	9	15	Robert Clyde	2S	170	65
2	12	0692	1.1	63+	-3S	Lembruch, G.F.R.	1	10		6	N. Wieth-Knudsen		180	
2	26	2291	5.5	56-	12S	Garner, NC	1	3	8	15	Robert Melvin			

When there is a substantial wind, especially during cold weather, observers should plan more time than usual to select sites, such as a grove of trees or building, which gives some protection. Allow time to explain what you plan to do to a farmer, so that you can obtain permission to set up in the leeward side of one of his buildings without being attacked by his dog. During a recent successful observation of a graze of a faint star during a strong wind, I set up my telescope in a large equipment shed through whose entrance the moon could be seen. It was almost like being in an observatory!

For at least one recent graze where we calculated shifts based on both the Yale Catalog data for the star and on the analysis of (mainly total) occultation data for the star, as described above, there was a significant difference between the two calculations, and the observations favored the Yale computation. This may be related to a problem that we found when we analyzed observations made near the edges, and then near the center, of the paths of the total solar eclipses of 1715 and 1925: The correction to the solar radius determined from the edge data differed from the value derived from the central observations. There could be significant systematic errors in Watts' lunar limb correction data for the polar regions compared with the rest of the moon. We plan to look into this possibility in more detail, by analyzing observations of grazes of the same star observed at both the northern and southern limbs, and comparing the results with the positional corrections derived from total occultation data. In the meantime, there is probably still some value in computing Yale Catalog shifts for grazes of stars south of declination -4° whose position source quoted in the graze predictions is "Z.C." or "G.C." and which are not in the Perth 70 Catalog.

In the list of grazes on p. 95 of *o.n.* 2 (9), the numbers for the graze of Regulus (ZC 1487) on 1980 June 18, Flamingo, FL expedition, need to be increased, since one observer was very late in sending in his report. # Sta should be 16 and # Tm should be 63. In reference to the article about Regulus starting on page 100 of the same issue, the star's importance is increasing and the jinx is being broken, as can be told from the account of the January A.A.S. meeting on p. 129. Also, for the graze of Regulus last November 1, we fared rather better than we did in the mosquito-infested Everglades last June. We planned to observe the November graze from Maine or near Montreal, but extensive cloudcover from a low-pressure system along the Atlantic coast made us decide to catch a flight instead to Duluth, MN, where we met my brother, Douglas, and drove north with him and his wife to observe the event about 80 km farther north. In marked contrast to the Everglades, the temperature was -7° C., but we were suitably dressed and there was no wind. A beautiful aurora shimmered along the northern horizon, a rare sight for a "southerner" like me. The graze was one of the most spectacular I have seen; being on the bright side enhanced the experience since the occulting mountains could be seen. The bright bluish star contrasted strongly with the considerably fainter lunar limb. Since Joan had 5 events and I had 10, the trip's cost per event was much lower than that for the June graze. I only wish that we could have shared the Saturday morning spectacle with more observers; the low ecliptic latitude made timings of the graze especially valuable for Solar eclipse analyses. With a little more planning, we might have brought some borrowed eclipse equipment to photograph the event, perhaps even make a movie or videotape, so that some measure of the spectacle could be shared with others. In spite of cloudy skies, 25 observers lead by Andre Coulombe set up for the graze near Montreal. Luckily, the sky cleared only a minute before the graze started, so all had a good view of the graze. However, arrangements had been made with a local am standard-broadcast station to broadcast CHU time signals, but this failed; only static was broadcast. Five of the observers had short-wave radios and received CHU directly. With the timed sequences from these stations, it might be possible to establish absolute times accurate to a second or so for some of the other stations for which relative timings might be available from tape recordings. In any case, as far as I know, this was the last-observed graze of the current series of Regulus, which has now ended; it will be 8 years before the next series begins.

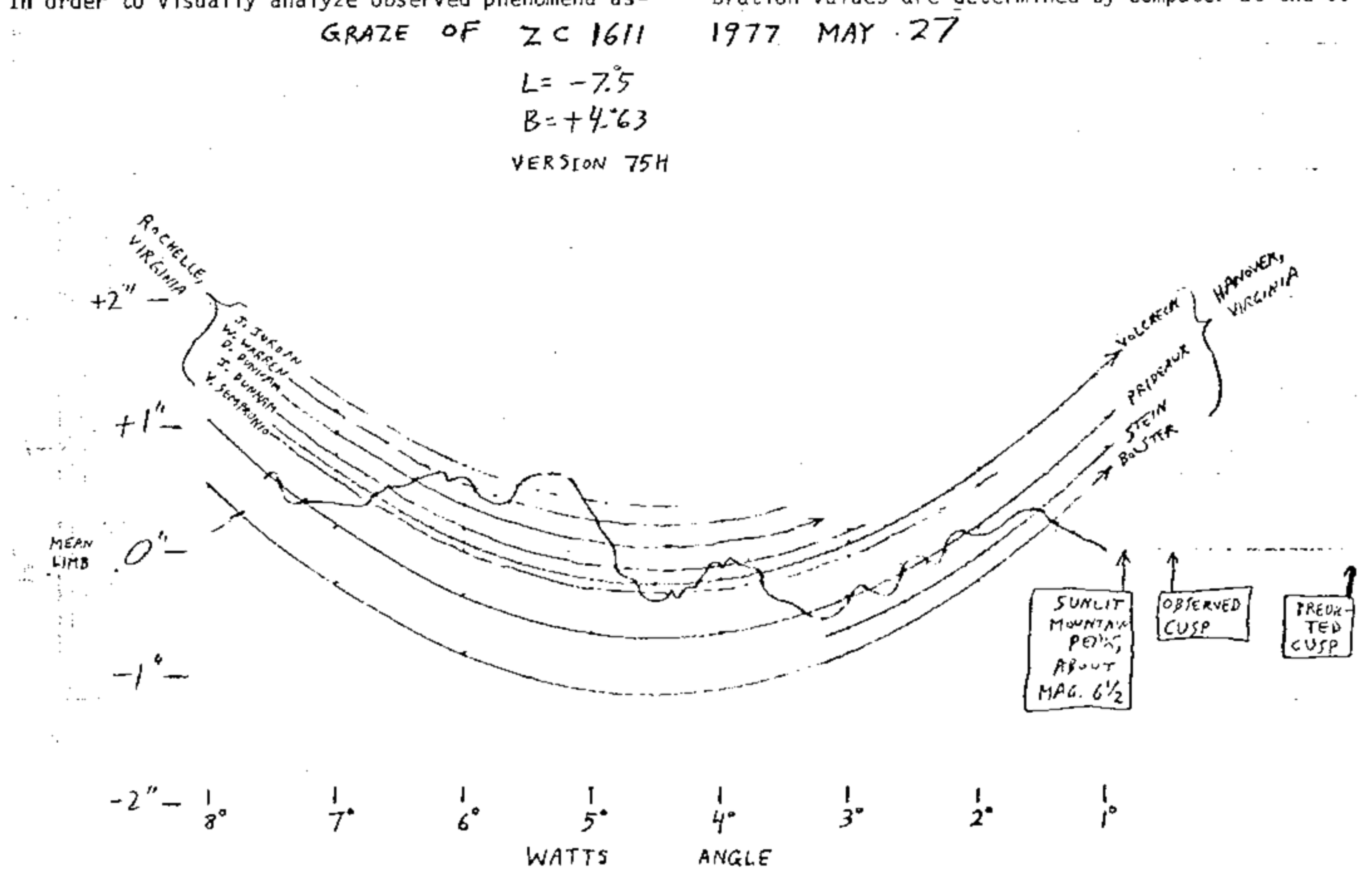
According to the British Astronomical Association's *Lunar Section Circular 15* (11) 94, 1980 November, Grant Blair, Bridge of Weir, reports that Aldebaran (ZC 692) faded to 7th mag. and remained like this for 0.25s at the bottom of a Lunar valley on 1980 September 29. This is reminiscent of 7th-mag. phenomena reported during the graze of 1979 September 12 in *O.N. 2* (7) 67, but it was not stated how close to grazing Mr. Blair's event was. Perhaps the last graze observations of the current Aldebaran series were made on February 12. It was daylight in Ohio, but the bright ruddy star contrasted well with the blue sky. I managed to time the graze in spite of having to hold the tube of my 25-cm reflector with my hands; an Allen wrench needed for the assembly of the telescope mount had been lost, which I discovered 15 minutes before the event. Jean Meeus notes that the last occultation of the series, visible from Greenland, Iceland, and Spitsbergen on 1981 April 8, is not listed in *The Astronomical Almanac for 1981*; an occultation of Mercury in Antarctica and southwestern Australia on April 3 is also not given. Dr. N. P. Wieth-Knudsen has computed the southern limit of the April 8 event, finding that it is entirely in the ocean. However, only a 2-minute occultation, qualifying as a graze, is predicted for Cape Akraberg, the southern tip of Suduroy, the southernmost of the Faroe Islands, part of Wieth-Knudsen's native Denmark. If you miss it, you won't have another chance for Aldebaran until 1997. After April, Antares will be the next-occulted first-mag. star, in 1986.

REDUCTION OF GRAZING OCCULTATIONS

Robert L. Sandy

Explanation of Reduction Profile:

In order to visually analyze observed phenomena associated with grazing occultations, the predicted profile of the moon's limb (i.e. edge) in the graze region must first be plotted; this is done through the use of limb correction charts by Watts.[1] To draw the profile, the moon's topocentric librations must be known for the time of the graze. These libration values are determined by computer at the U.



PROTOTYPE FOR PORTABLE OCCULTATION PHOTOMETER SHOWN; OTHER NEWS FROM A. A. S. MEETING

David W. Dunham

The 157th meeting of the American Astronomical Society was held in Albuquerque, NM, during 1981 January 11-14. Abstracts of papers presented at the meeting have been published in *Bull. Amer. Astro. Soc. 12*, No. 4. Some of the papers were given as displays rather than as oral presentations. A display which will be of particular interest to many IOTA members was "A Portable Occultation Photometer" by Peter C. Chen, University of Texas, and William H. Sandmann, Harvey Mudd College. Thier abstract is printed below:

"We have designed and built a photometer system of light weight (<5 lbs) and low cost, to encourage participation of amateur astronomers and small college observatories in lunar and planetary occultation observations. The system, which is of simple modular form and can be put together without unusual mechanical or electronics skills, consists of two major components:

a) Photometer Unit (cost ≈$100) - This consists of a side-on PMT (EMI 9781) fitted inside a PVC crosspiece which also contains a beamsplitter and an aperture slide. Attached to the crosspiece is a metal housing containing a high voltage supply, a DC amplifier, and a voltage to frequency converter. The entire photometer unit attaches to a telescope in place of an eyepiece.

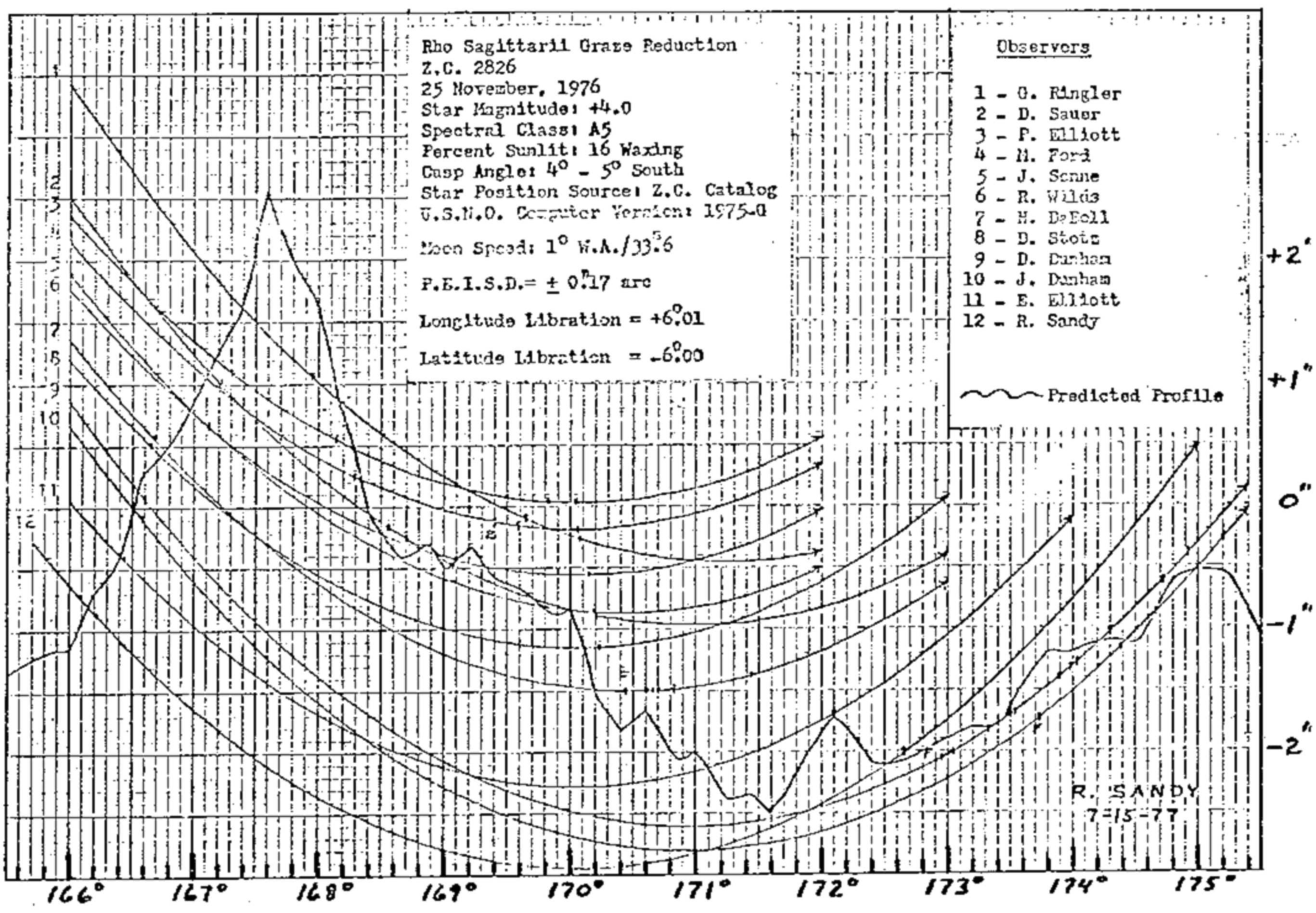
b) Controller (cost ≈$150) - This is a microprocessor system with keyboard and display. The system is programmed to synchronize with WWV time signals, display time, accumulate PMT signal pulses at 1, 2, 4, or 50-ms time resolution, display the data either with a series of LED's or on an oscilloscope, and output the data to a standard audio cassette tape recorder. Two simultaneous PMT channels can be accomodated. We have incorporated a variety of hardware and software features to optimize error-free operation.

The recorded data can be read by other larger computers (TRS 80, NOVA, etc., at Texas or elsewhere) for data reduction. A prototype system has been successfully tested in the laboratory and is currently undergoing field trials."

After the trials are successfully completed, detail-

S. Naval Observatory, Washington, D.C., and are shown as symbols L (longitude) and B (latitude) on the reduction profile.

Next, the *predicted* path of the star in relation to the moon is plotted for each observing station (again, computed by the U.S.N.O. and based on the *reported* geographical coordinates *and* elevation of each observing station) with the reported points of star contact with lunar features indicated. For each observing station, the star moves along a curved path from left to right, station designations being indicated at the left hand side. Periods when the star was reported visible are indicated by a solid line, while during periods of invisibility, the line is broken with either "dots" or clear spac-



ed designs will be prepared for those interested in duplicating the system; only a few key components would be assembled in Texas. These might be available in June, in time for the symposium of International Amateur-Professional Photoelectric Photometry to be held with the annual Apollo Rendezvous in Dayton, OH, and chaired by Russell Genet. The beamsplitter in Chen and Sandmann's system allows simultaneous visual monitoring of occultations.

About 20 fringes were recorded during the daylight occultation of Regulus at Kitt Peak Nat. Obs. on 1980 Jun 18 by Don Wells and co-workers, who observed at 1.6 μm in the infrared with the Mayall 4 m telescope. A rectangular pupil mask was used to help produce the highest signal-to-noise occultation record to date. Special modifications of the analysis program were necessary to take advantage of the observational accuracy. Richard Radick also obtained good records of another Regulus occultation at Cerro Tololo Inter-American Observatory the night of 1980 March 28. The derived angular diameters, including also the Narrabri intensity interferometer result, are listed below in milliarcseconds:

1.41 ±0.08	KPNO
1.40 ±0.12	CTIO (yellow, λ = 5768Å)
1.52 ±0.11	CTIO (blue, λ = 4356 Å)
1.32 ±0.06	Narrabri (λ = 4385Å)

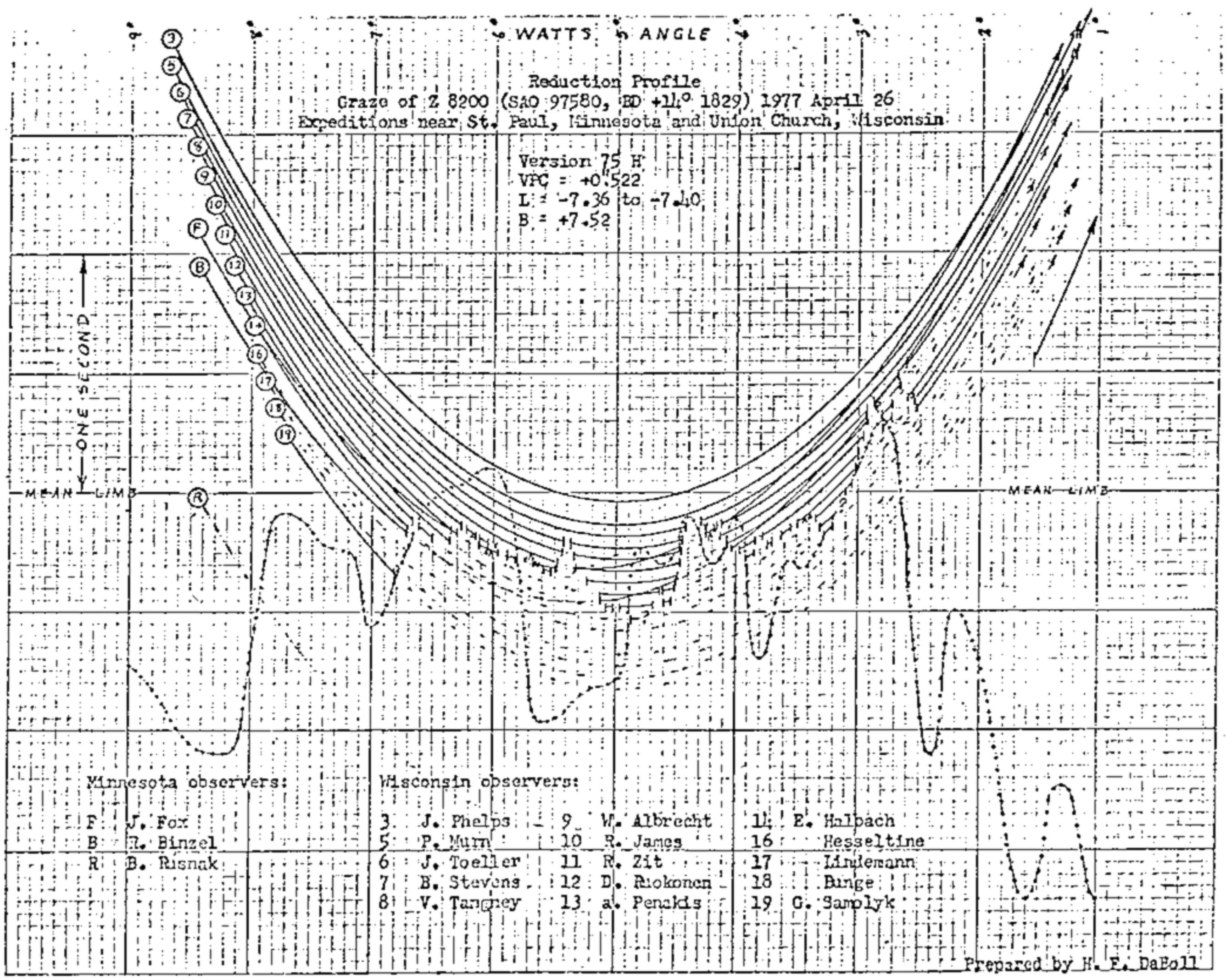
In spite of the star's small angular diameter, the determination is accurate to better than 10%, almost an order of magnitude better than was thought possible from Lunar occultation records a few years ago. The implication is that the diameters of bright Solar-type stars can be measured from high-quality Lunar occultation records.

Variations in the diameter of the Sun from eclipse observations were reported by Joan Dunham, including the new result from the 1925 eclipse mentioned on p. 114 of the last issue. I gave a paper on the results of recently-observed asteroidal occultations published on pages 139-143 of this issue of *O.N.*

es between. A dashed line indicates that observations were discontinued or that no timings were made because of timing equipment failure, etc.

Explanation of Abbreviations and Symbols Used on Reduction Profiles:

V.P.C.--Vertical Profile Correction applied to predicted profile to bring it into closer agreement with observations (usually VPC is set at 0".00 in preliminary reductions). H.P.C.--Horizontal Profile Correction in the predicted position of the limb mountains (typical value is 0°.2).



LOCAL CIRCUMSTANCES OF ASTEROIDAL AND PLANETARY OCCULTATIONS AND APPULSES FOR 1981

Local predictions, which supplement the tables of general data published on pages 116-119 of the last issue, have been computed and distributed to all IOTA members receiving graze predictions, by Joseph E. Carroll, 4216 Queen's Way, Minnetonka, MN 55343, telephone 612, 938-4028. Henceforth, these predictions are established as a service for all IOTA members. IOTA members who have not been receiving grazing occultation predictions are being added to the file of graze station data, since this is the basis of Carroll's predictions. Such observers will also receive Lunar graze predictions, but only for favorable events which are potentially observable from their station. They can obtain graze predictions for a larger area, if desired, by sending travel radii specifications to IOTA, P.O. Box 596; Tinley Park, IL 60477, U.S.A.

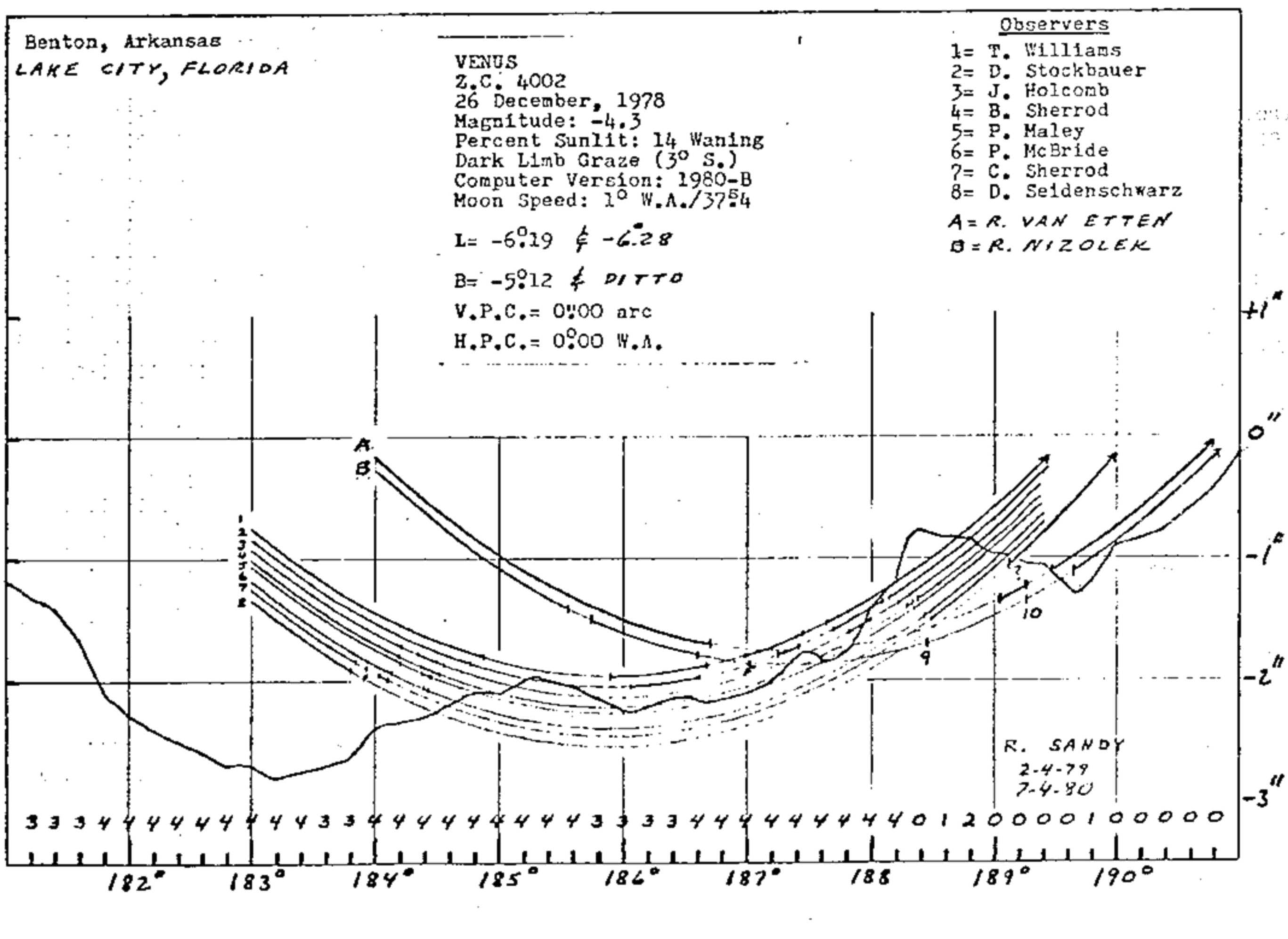
Several observers interested solely (or primarily) in planetary and asteroidal occultations subscribe to *o.n.*, but are not IOTA members and have not been sent these predictions of local circumstances. We are not going to maintain two station files, one for grazes and one for planetary/asteroidal appulse predictions, in our computerized IOTA records in Illinois. Current non-IOTA *o.n.* subscribers who want the appulse predictions are encouraged to join IOTA by sending an additional payment ($3 for North Americans) to IOTA in Tinley Park. The local circumstances predictions will then be sent automatically each year as long as IOTA membership is maintained. Non-IOTA members can obtain the planetary/asteroidal appulse predictions by sending Joseph Carroll their coordinates and either a self-addressed stamped envelope (for those in the U.S.A.) or a payment of $1.00 payable to Joseph E. Carroll (for foreign observers). Such requests need to be sent annually by non-IOTA members.

For each input event, the local circumstances predictions include the U.T. and distance (in arc seconds, kilometers, and occulting object diameters) of closest approach, and the altitude and azimuth of the occulted star, the Sun, and the Moon. No data are printed if the star is below the horizon more than an amount proportional to an estimate of the occulting object's along-track (time) error, or if the star is fainter than 6th mag. in daylight.

Computer Version (e.g. 78A, 80D, etc.)--the designation of the set of empirical corrections made to the lunar ephemeris at the U.S.N.O. that were used in making the reduction.

Symbols: B (blink; a D followed by an R in less than one half second); F (flash; an R followed by a D in less than one half second); ? (uncertain timings or events as reported by observer, OR observ-

OBSERVED DATA FROM Z.C. 1008 GRAZE OF 10/13/68; WHERE L=-3.3 & B=-6.6



NEW DOUBLE STARS

David W. Dunham and Joan Bixby Dunham

Table 1 lists additions and revisions to the special double star list of 1974 May 9 not listed in previous issues. The columns and general format were described on p. 3 of *O.N. 2* (1).

If you suspect that a star may be a previously unknown double, or if you can confirm or improve data from a previous discovery, based on an occultation observation, please send a report to: David Dunham, P.O. Box 488, Silver Spring, MD 20907, USA. The report should include the star's SAO number (DM and USNO reference number, if non-SAO), the Z.C. number (if any; Z.C. numbers are four-digit numbers with no prefix letter under USNO REF. NO. in the USNO predictions), the date, the position angle of the occultation, and, if possible, an estimate of the time between steps and the brightness of the secondary relative to either the primary or the total light (primary plus secondary). It is helpful also to report the star's magnitude and (if any) double star code given in the predictions. If you have the photoelectric option, also give the predicted radial rate. For those without the photoelectric option, the radial rate can be estimated if you give the CA and the Moon's altitude and azimuth.

This list is the longest list of updates which we have ever published. It is due almost entirely to the efforts of G. M. Appleby, who published his results in an article, "Fading Occultations of Stars by the Moon: 1943-1977" in *J.Brit.Astron.Assoc. 90* (6) 572, 1980. These entries are identified simply by *JBAA* in the "DATE, DISCOVERER, NOTES" column, this meaning that they were taken from the just-

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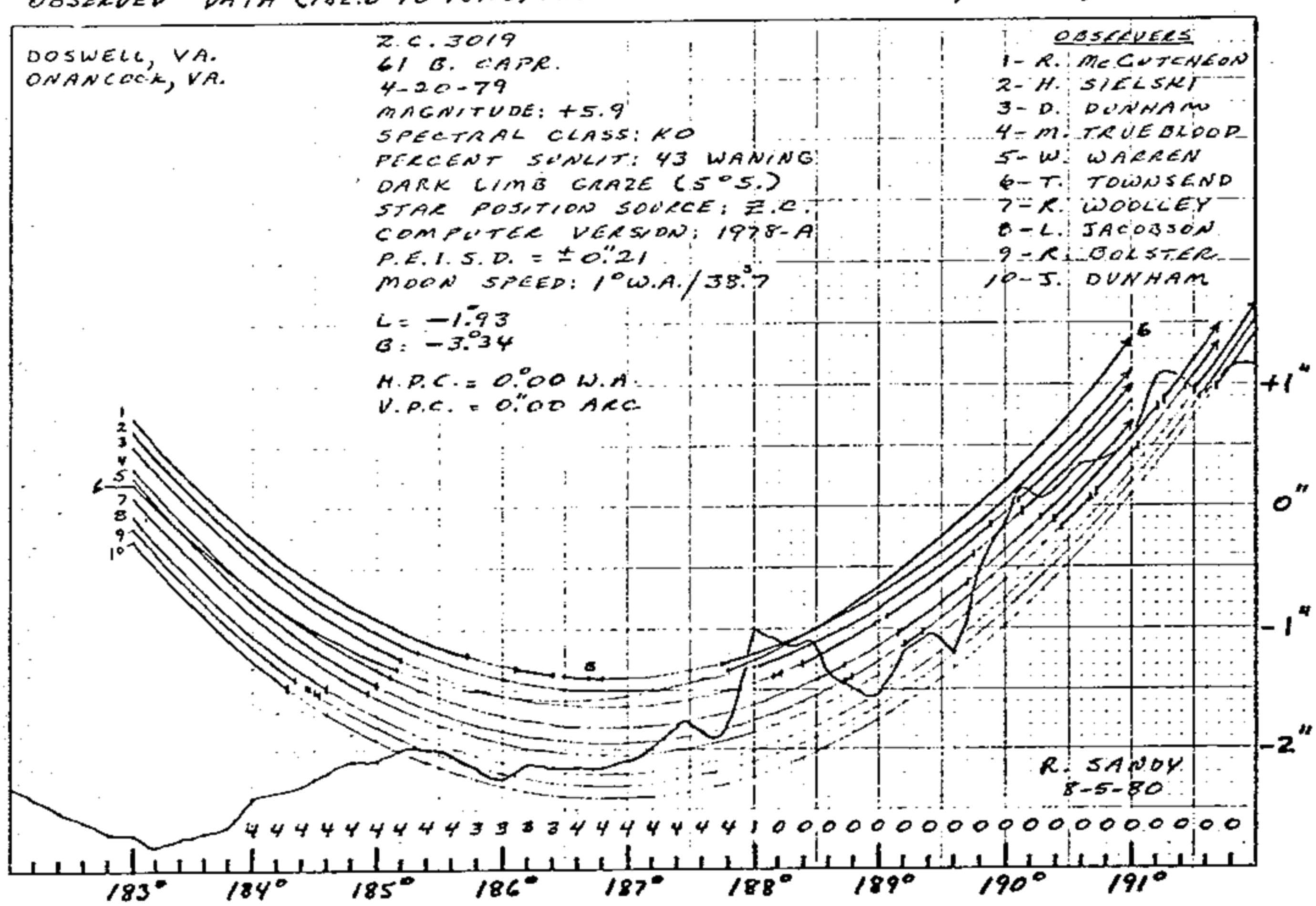
er's timings are questioned because of an obvious discrepancy of timing(s) when compared with timings made at other observing stations); and A.T. (Altered Time; an obvious error in the reported time has been adjusted for reduction purposes). It should be noted that (1) a reported timing is altered only when there is considerable indication that a particular timing may be in error by several seconds (in most cases this amounts to either a thirty-second or sixty-second mistake in the reported timing), and (2) that even though the timing has been altered, it should not be considered as being as accurate as other reported timings.

I prepare reduction profiles, and correspondence about reductions should be sent to me at 7901 East 88th Terrace; Kansas City, MO 64138; U.S.A.

Reference

1. C. B. Watts, "The Marginal Zone of the Moon," *Astronomical Papers of the American Ephemeris, Vol. 17*, U.S. Government Printing Office, Washington (1963).

OBSERVED DATA (182.0 TO 187.8) FROM Z.C. 1008 (10-13-68); L = −3.3; B = −6.6



cited reference. L. V. Morrison and G. A. Wilkins gave Mr. Appleby access to the approximately 80,000 occultation observations which had been collected by HMNAO for the years 1943 to 1977, and helped with the draft of his paper. Appleby investigated why 423 occultations of stars were observed to occur non-instantaneously. He found that 160 of the observations can be explained by known duplicity of 140 of the stars. A further 19 observations can be attributed to effects of stellar angular diameter or diffraction. Appleby conjectures that 166 observations of 130 stars refer to previously unrecognized doubles. Seventeen of these stars were already in my list since they had been resolved spectroscopically, by speckle interferometry, or during occultations which I already knew about. Some of them were in my list with code K based on observations made since 1977, or in the 1920's and 1930's reported in the

TABLE 1A, NEW DOUBLE STARS, 1981 FEBRUARY 22

SAO/BD	ZC	M	N	MAG1	MAG2	SEP	PA	MAG3	SEP3	PA3	DATE, DISCOVERER, NOTES
76126	0536	T	V	5.7	7.7	0"1	90°				*JBAA*
76573	0647	T	Y	6.3	6.3	0.1	90	7.6	19"4	24°	*JBAA* (comp. AB; ADS 3161)
76591	0652	T	Y	7.2	7.2	0.1	90	8.8	28.9	290	*JBAA* (comp. AB; ADS 3179)
76601	0656	T	V	5.2	5.2	0.1	110				*JBAA*
76862	0743	T	T	6.4	6.4	0.1	90	9.9	94.6	289	*JBAA* (comp. AB; ADS 3547)
92572*		V	O	9.4	9.4	.217					Orbit by Valbousquet, last obs. 1976.88 (ADS 1321)
93757*		T	V	9.0	9.0	0.2	75				1981 Jan 16, R. Hays, Worth, IL
93957*	0671	P	V	4.0	5.0	.02					See text; period only 140 days
94227	0741	T	X	6.5	6.5	.08	240				1980 Sep 2, D. Büttner, Karl-Marx-Stadt, GDR
95795	1003	T	Y	8.0	8.0	.05	32	8.1	20.0	210	*JBAA* (ADS 5166)
96178*		T	X	9.2	9.2	.05	153				1980 Mar 24, R. Baldridge, Mountain View, CA
96573		T	K	9.4	9.4	0.1	90				1980 Apr 20, P. Wade (*BAA Lunar Sec. Circ. 15*, p. 75)
97468	1203	T	V	7.9	7.9	.05	90				*JBAA*
98662	1415	T	Y	7.0	7.0	0.1	90	10.0	41.2	80	*JBAA* (ADS 7448)
109964	0226	T	Y	7.2	7.2	0.1	90	10.7	4.1	77	*JBAA* (ADS 1214)
109985		T	K	9.8	9.8	0.1	65				1980 Dec 17, R. Baldridge, Mountain View, CA
110723*	0405	T	V	4.5	8.5	.05	133				1980 Jan 25, R. Baldridge, Mountain View, CA
118678	1614	T	Y	9.6	9.6	0.1	90	11.0	12.4	96	*JBAA* (comp. AB; ADS 8068)
139086	1866	T	Y	6.7	6.7	0.1	90	11.1	20.9	55	*JBAA* (ADS 8732)
146388*	3362	V	O	6.1	8.1	.47					Orbit by Baize, last obs. 1978.68 (ADS 16365)
157831	1906	T	Y	8.5	8.5	0.1	90	10.5	42.6	98	*JBAA*
162076*	2768	T	K	9.2	9.2	0.1	90				1978 Oct 9, G. Blow, Carter Observatory, New Zealand
162251*		T	K	9.2	9.2	0.1	90				1978 Oct 9, G. Blow, Carter Observatory, New Zealand
162883*	2876	T	Y	6.2	6.2	0.1	90	8.9	45.6	42	1978 Aug 16, G. Wingate, Auckland,NZ (comp. AB; ADS 12767)
163811		T	K	7.4	9.0	0.5	117				1980 Oct 18, J. Van Nuland, San Jose, CA
164623*		T	K	9.5	9.5	0.1	90				1978 Nov 8, G. Blow, Blenheim, New Zealand
165337		T	X	9.9	9.9	0.1	92				1980 Dec 14, R. Baldridge, Mountain View, CA
165355		T	K	9.7	9.7	0.1	99				1980 Dec 14, R. Baldridge, Mountain View, CA
186161	2601	T	Y	7.5	7.5	0.1	90	13.0	8.9	26	*JBAA*
+18° 1367		T	X	10.4	10.4	.05	147				1980 Mar 24, R. Baldridge, Mountain View, CA (= X09910)

[Ed: Separate TABLE 1B is used for 102 of the *JBAA* stars; those for which it is assumed that the primary and secondary magnitudes are equal, and that they are separated by 0"1 at p.a. 90°. Where these assumptions are not used and/or where third component data are shown, the stars appear in Table 1A.]

SAO/BD	ZC	M	N	MG1	SAO/BD	ZC	M	N	MG1	SAO/BD	ZC	M	N	MG1	SAO/BD	ZC	M	N	MG1	SAO/BD	ZC	M	N	MG1
75476	0387	T	V	7.7	80125	1253	T	X	8.2	109256	0067	T	K	9.2	146652	3432	T	K	7.1	165032	3284	T	K	7.9
75968	0509	T	K	8.9	80378	1308	T	V	5.5	109369	0089	T	K	7.3	146774	3472	T	K	7.8	183797	2256	T	K	7.7
75979	0513	T	K	8.7	80886	1408	T	K	8.2	110264	0291	T	K	7.9	147017	3529	T	K	7.6	183900*	2269	T	X	6.2
76173	0546	T	K	7.8	92395	0197	T	K	7.8	110286	0298	T	K	8.0	147045	3537	T	K	7.6	184607	2407	T	V	7.7
76236	0562	T	X	7.4	92559	0246	T	K	9.7	110408	0327	T	K	5.3	158385	2028	T	K	7.3	184897	2443	T	K	6.6
76275	0573	T	K	7.6	92774	0302	T	K	7.2	118095	1478	T	K	8.0	158836	2117	T	K	6.1	184982	2452	T	K	7.5
76286	0574	T	K	7.6	92803	0313	T	K	8.3	118111	1482	T	K	7.1	159146	2184	T	K	7.8	185589	2537	T	K	8.2
76393	0595	T	K	7.6	92979	0370	T	K	6.9	118181	1500	T	K	8.9	159175	2189	T	K	7.8	185655	2545	T	X	7.2
77350*	0849	T	X	7.3	93002	0375	T	K	7.6	128069	3417	T	X	7.6	159402	2230	T	X	7.6	185815	2562	T	K	7.9
77647	0887	T	K	7.8	93034	0393	T	K	7.6	128621	0018	T	K	6.8	159587	2279	T	X	7.0	185852	2568	T	K	9.3
77858	0911	T	K	7.1	93320	0462	T	K	6.7	137963	1604	T	K	6.9	159888	2352	T	K	7.5	185900	2575	T	K	7.6
78146	0949	T	K	8.5	93327	0464	T	K	7.2	138824	1795	T	K	7.9	162050	2764	T	X	7.1	186070	2591	T	K	7.3
78348	0982	T	X	7.6	93487	0516	T	K	8.1	139022	1849	T	K	7.0	162234	2794	T	K	7.5	188387	2869	T	K	9.0
78390	0987	T	K	8.5	93981	0680	T	K	7.5	139559	1978	T	V	7.4	162413	2814	T	K	5.8	188863	2928	T	X	7.3
78968	1067	T	K	8.0	98019	1297	T	K	7.6	139732	2020	T	K	7.4	163107	2908	T	K	7.7	188889	2929	T	K	7.9
79286	1108	T	K	7.7	98133	1319	T	K	8.3	145455	3154	T	K	8.2	164461	3155	T	K	7.6	189321*	2984	T	X	7.7
79352	1117	T	K	5.9	98235	1332	T	K	6.5	145905	3247	T	K	7.8	164600	3177	T	K	6.8	189330	2985	T	K	7.7
79391	1127	T	V	6.7	98521	1387	T	K	7.6	146062*	3285	T	X	6.9	164711	3205	T	K	7.6	190147	3102	T	K	7.7
79483	1143	T	K	7.6	98673	1418	T	K	6.7	146363	3354	T	K	8.7	164811	3222	T	K	7.9					
79553	1150	T	X	7.6	99049	1506	T	V	7.9	146451	3380	T	K	7.0	164840	3231	T	K	8.2					
80035	1244	T	K	9.7	99321	1578	T	K	7.6	146620	3425	T	K	5.4	164973	3267	T	K	8.0					

Union Observatory Circulars. The codes for these stars have been upgraded to X or V. For the known doubles, Appleby computed the predicted time between occultations of the components and the magnitude drop. He compared these with the observers' comments, which were usually "gradual" or "steps." He found that, regardless of the duration, events with magnitude drops of 1.0 or less were usually reported "gradual," while step events resulted from magnitude drops greater than 1.4 and durations more than 1^s. Appleby's list includes only Z.C. stars, and he erroneously notes that the Z.C. is complete to magnitude 7.5 (it is actually complete to mag. 7.0 by intention, although there are a few stars in the Zodiac, mainly variables, which are slightly brighter at maximum light). In any case, of the 2935 Z.C. stars brighter than mag. 7.6, approximately 430 (15%) are known doubles, and adding Appleby's stars raises the percentage to 19, which Appleby compares to the 25% that may be expected to be visual doubles based on star catalog statistics given in Allen's *Astrophysical Quantities.* Unfortunately, Appleby gives no do-documentation of the individual events, only noting the number of reported non-instantaneous observations for each star (usually 1). In the case of one observation, I have assigned code K, with code X for two and code V for three or more. I have arbitrarily assumed that the components were equal in magnitude, lacking further information. For the same reason, I have given 90° for the position angle (all were disappearances) and 0".1 (to be regarded as an upper limit; could be as small as 0".02, or actually sometimes greater than 0".1) for the separation. Appleby found only five reports of non-instantaneous emersions of stars previously known to be only single, and rejected these due to the inherently unexpected nature of reappearances. Nevertheless, Appleby's carefully-prepared list is very useful for indicating stars which should be of special interest to occultation observers and double star specialists. Some of the stars have previously-known faint, distant companions which could not explain the reported phenomena; these are now suspected triples.

The I.A.U. Double Star Commission's *Circulaire d'Information* No. 82 (1980 October) lists new orbital elements for three Zodiacal stars. One of these, SAO 76256 = ZC 569 = ADS 2799, previously had an orbit determinted and is already in my list with code O. SAO 92572 = ADS 1321 and SAO 146388 = ZC 3362 were in the list of visual doubles but had no previously-determined orbit.

In *The Observatory 100* (1039) 206, 1980 December, David Evans and David Edwards stress the importance of the recently-resolved (see *O.N. 2* (8) 92) star θ^2 Tauri = SAO 93957 = ZC 671 for occultation observers since it is a spectroscopic binary in the Hyades with a separation of only about 0".01. He reports an observation by Wayne Osborne giving a separation of 0".0083 in direction 335° (with local Lunar slope -9°.5) and Δm of 0.65 at λ 4200 Å on 1980 Jan. 27. Since the spectroscopic period is only 140 days, Osborne's observation can not be readily combined with the earlier Texan result. The authors point out that occultations will occur until 1982 February 3. Actually, the series of ZC 671 occultations ends sooner, and it is already too late; only a few more occultations will be visible from the Arctic. We probably will have to wait until 1997 to obtain more occultation data for this star.

Richard Nolthenius reported a couple of 8th-magnitude events during the 1980 Aug. 20 graze of 5.0-mag. ZC 2399 = SAO 160046 near Soledad, CA. The PA was 14°. Nolthenius feels that diffraction was responsible rather than duplicity. Don Stockbauer feels the same way about a 7.5-mag. event he saw at a graze of 6.6-mag. ZC 2043 = SAO 139834 at PA 211° near El Campo, TX, on 1980 Dec. 31. During a graze of 6.6-mag. ZC 1420 at Patterson, CA, on 1980 Oct. 4 (PA 11°), 8 of the 13 observers reported a faint flash or "glow" which most thought looked peculiar. For example, Gerry Rattley stated that it was not stellar, but diffuse, "like a street lamp behind a house." Only three of the observers timed the phenomenon, and the times are different, and do not match with valley bottoms inferred by timings made by observers to the north, according to Jim Van Nuland's report.

Harold McAlister reports that his new intensified CCD speckle camera will be ready for observations in a few months. This will extend his speckle interferometry to fainter objects (most SAO stars will be within reach) than he has been able to resolve previously.

In the new double star list published in *O.N. 2* (7) 71, documentation was not provided for 9 entries, data for five of these being given in subsequent issues. The other four, with SAO numbers of 162076, 162251, 162883, and 164623, were observed in New Zealand and are documented in Table 1.

Double star codes for non-SAO stars can now be updated in USNO's computer files by USNO reference (usually X) number, and this has been done for all non-SAO stars in the special list which are in the XZ catalog. The X numbers of non-SAO doubles which have not been published previously are given in Table 2.

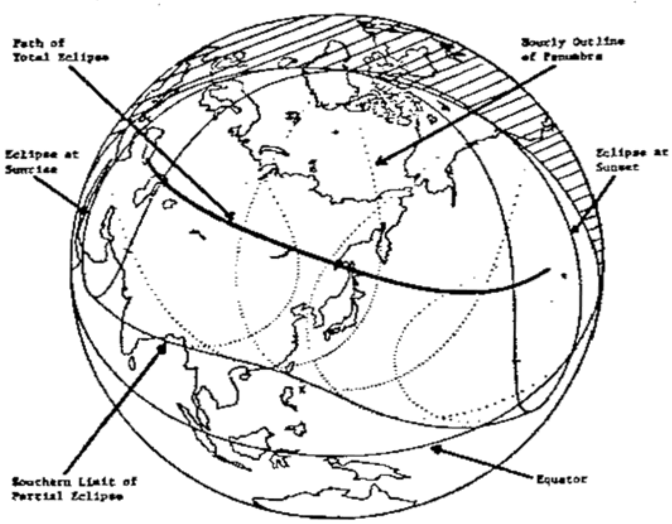
Table 2. USNO-DM crossreference

B. D.	USNO	B. D.	USNO
+23° 1311	X08814	+17° 1416	J03402
+21 1317	X09497	+15 0269	X02549
+19 0544a	X04604	+15 0340	X03327
+18 0929	X07449	+15 0409	X03870
+17 1043b	X07818	+13 1961	X13159
+17 1246	J02713	+12 1926	X13466
+17 1315	X09426		

SIBERIA 1981

Fred Espenak

The Soviet Union will witness a total solar eclipse on 1981 July 31. The umbra first touches the earth at 2:18 U.T. at the eastern end of the Black Sea. Heading in a northeastern direction, the shadow quickly crosses the Caucasus Mountains and races over the northern part of the Caspian Sea. Only one minute after first contact [sic], the umbra enters Kazakh, SSR, where the sun will have an altitude of 10° and totality lasts 56 seconds. Cutting a 95-kilometer-wide path through the Steppes, the umbra crosses into southern Siberia, where a number of cities lie in its path. South of the center line, Belovo will see a total eclipse lasting 91 seconds, with the sun 35° above the horizon. Seventeen min-



utes later, Bratsk will enjoy 109 seconds of totality, with a solar altitude of 44°. Moving due east, the shadow skirts the northern tip of Lake Baikal, the world's deepest lake (5315 feet) at 3:10 U.T. Maximum eclipse occurs fifteen minutes later in eastern Amur, where the sun will stand 54° above the horizon during 126 seconds of total eclipse.

The umbra leaves Asia at 3:48 U.T. as it quickly crosses Tatar Strait and Sakhalin. Last major landfall occurs among several of the Kuril Islands at 4:20 U.T. The path of totality stretches out across the northern Pacific, where it crosses the International Date Line at 5:03 U.T. The Hawaiian Islands will observe a 90% partial eclipse at sunset on July 30 as the umbra passes 500 kilometers north and leaves the earth at 5:14 U.T.

As many as five planets may be visible to the naked eye during totality. Venus will be obvious, 29° east of the sun and shining at magnitude -3.4. Mercury should also be apparent only 11° west of the sun at -1.2. Mars will be difficult as it shines at +1.8 about 30° west. Jupiter (-1.4) and Saturn (+1.2) are at an eastern elongation 58°, and are 2° apart. The pair will be low in the east over the Siberian half of the eclipse path.

Weather prospects in Kazakh and southern Siberia are favorable, although seasonable rainfall statistics tend to increase as one travels east along the path. However, the average precipitation is only 5 to 10 inches a year over most of central Asia. Daytime temperatures typically range 75°-85° F in Kazakh and 20° F cooler in Siberia. In any case, final site selections may be determined by the Soviet government rather than by the individual.

For a complete report on the 1981 eclipse, send a self-addressed envelope (U.S. observers should also provide stamp) to me at 12700 Bridle Place; Bowie, MD 20715; U.S.A.

[Ed: The table is shortened from the version provided by Dr. Espenak. Copies of the unabridged table are enclosed for subscribers in countries along the umbral track. Also see the author's final paragraph.]

PATH OF UMBRA AND CENTER LINE DATA - TOTAL SOLAR ECLIPSE OF 1981 JULY 31 - ET-UT = 51.0 SECONDS

	NORTHERN LIMIT		SOUTHERN LIMIT		CENTER LINE								
U.T.	LATITUDE	LONGITUDE	LATITUDE	LONGITUDE	LATITUDE	LONGITUDE	MAGNITUDE	ALT.	AZI.	MAJOR AXIS	MINOR AXIS	PATH WIDTH	DURATION
LIMITS	42°14!9	-39°32!9	41°47!8	-39°59!4	42° 1!4	-39°46!5	1.0132	0°0	65°1	-	45.3	60.9	0m42.s
2:20	46 13.3	-51 03.3	46 22.4	-53 48.4	46 19.0	-52 15.1	1.0163	10.3	74.3	311.5	55.8	74.3	0:56.
3:00	56 25.3	-100 50.4	55 30.6	-101 33.6	55 58.0	-100 59.6	1.0249	43.9	130.3	122.1	84.7	104.9	1:50.
3:40	54 30.0	-130 44.2	53 31.9	-130 19.7	54 00.9	-130 19.0	1.0267	54.2	186.4	111.6	90.5	110.9	2:06.
4:20	47 30.9	-153 38.5	46 46.7	-152 38.7	47 08.9	-152 55.6	1.0253	48.5	238.6	114.7	85.9	109.4	1:54.
5:00	35 28.1	-177 57.6	35 09.6	-176 39.5	35 19.0	-177 05.6	1.0196	25.9	274.8	153.1	66.8	90.7	1:15.
LIMITS	25 5.3	+157 53.7	24 39.9	+158 12.7	24 52.6	+158 03.3	1.0119	0.0	290.3	-	41.0	55.0	0:38.

PUTTING USNO "GRAZE NEARBY" MESSAGES TO WORK

Mark Gingrich

No doubt you have noticed the occasional message "GRAZING OCCULTATION OF {Star #} NEARBY" on your U.S.N.O. total occultation predictions. Juxtaposed with this message is an equation

(1) Lat. = A + m (West Long. - B)

where the values A and m vary from graze to graze. The B value is constant throughout your predictions.

By simply plugging a few longitude values into this equation, the corresponding latitudes of points along the graze path are generated. Plot these points on a map to get a more complete picture of your position near the graze track.

Alternatively, the distance and heading of the nearest point on the graze path from your home, or some arbitrary point, can be calculated. The recipe is as follows: for an observer at west longitude λ and latitude ϕ, find the value

(2) $L = (B - \lambda) \cos \phi$, (3) $M = m / \cos \phi$.

Next, determine X from equation 4

(4) $X = \dfrac{M (A - \phi) + L}{M^2 + 1}$.

X is inserted into equation 5 to acquire Y

(5) $Y = A - MX$.

The distance (in kilometers) to the nearest point on the graze path is found with equation 6

(6) $R = 111 \sqrt{(X - L)^2 + (Y - \phi)^2}$.

The heading (azimuth angle) of this point is defined by equation 7

(7) $H = 90° - \tan^{-1} \{(Y - \phi) / (X - L)\}$.

Be careful when taking the arc tangent; the value must be in the correct quadrant. If your calculator has a "rectangular to polar conversion" key, the job is made easier. Also, note that unpalatable negative values for H can be remedied by adding 360°. The heading for north is 0°, 90° for east, etc.

Here is a sample calculation. The USNO predictions show this "GRAZE NEARBY" message:

Lat. = 37.68 - 0.36 (West Long. - 122.18) .

Hence, A = 37.68, m = -0.36, and B = 122.18. The observer is at west longitude λ = 122.75 and latitude ϕ = 37.5. From the recipe, we find R = 2.5 km and H = 156°, meaning the graze path is 2.5 km from the observer at a heading of 156° (roughly SSE).

Finally, it should be stressed that equation 1 is an approximation; your computor, with the help of USNO, can supply you with more accurate graze limit predictions. The approximation gives reasonably good values [Ed: accuracy of the order of several miles] within 100 km of the coordinates printed on the top of your USNO predictions. Attempts to find the distance and heading for an observatory in Antarctica would be fruitless.

If you would like a copy of the (HP-41C programmable calculator) program I use for the above calculations please send a SASE to me at 2979 Northwood Drive; Alameda, CA 94501; U.S.A.

FROM THE EDITOR

Please note 1980 occultation count coupon enclosed.

In order to make our disclaimer a more permanent part of your *O.N.* file, the full text of the note inserted in the last issue at time of mailing is repeated here:

In view of the editorial comment on page 119, it is embarrassing to find that David Dunham's map of 1981 predicted planetary occultation paths does, indeed, appear in the January, 1981, issue of *Sky and Telescope*, which I did not see until after this issue of *O.N.* came back from the printer. Dr. Dunham had requested that the comment be inserted, probably because he looked under "Occultation Highlights," rather than "Celestial Calendar." H. F. DaBoll

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OBTAINING COORDINATES FROM MAPS

David Herald

I was interested to read Don Stockbauer's article on his experiment on dimensional stability of folded maps (*O.N.* 2 (9), 97). In his experiment, Don used a map having a scale of 1:24000, and presumably maps on that scale are available for the whole of the U.S.A. [Ed: Not yet.]. In the area where I live (Canberra, Australia), the largest scale maps available for the region at the moment are at a scale of 1:100000. At that scale, 1 mm corresponds to about 3", so the problem of dimensional stability of the map, both from folding and from moisture effects, is much more severe.

In any system of measurement, greatest accuracy is obtained by measuring from the nearest reference marks. In taking measurements of latitude and longitude from a map, the obvious way is to use a ruler and measure from the latitude and longitude marks (or the map boundary) and make the appropriate interpolation. However, any map I have seen has few marks for latitude and longitude. The most obvious markings are the grid lines [Ed: Non-existent on U.S.G.S. maps]. Provided one has the computational capability, the most accurate way to obtain a coordinate from a map is to determine the full grid coordinates (using a ruler), and convert these to latitude and longitude.

To illustrate the mathematics involved, I give below the formulae used. These are for the Australian Geodetic Datum, which differs from the North American Datum both in the precise values of the constants, and in being a metric system. However, the formulae will be of the same form.

For grid coordinates N (north) and E (east)
constants $k = 0.9996$
$e'^2 = 0.00673966$
$c = 6.399617$

$q = E\cdot 10^{-6}$ $\quad m = N/k$

find ϕ' from $m = 111133.35\,\phi' - 16039 \sin 2\phi' + 17 \sin 4\phi'$

This requires an iterative process to solve.

With $V^2 = 1 + e'^2\cos^2\phi$ $\quad n = k\cdot c/V$ $\quad t = \tan\phi$

Then $\phi = \phi' - \frac{1}{2}\cdot t\cdot(1 + e'^2\cos^2\phi)\cdot(q/n)^2 + \frac{1}{24}\cdot t\cdot(5 + 3\cdot t^2)\cdot(q/n)^4$

and $L = L_0 - q/(n\cdot\cos\phi) + (1 + e'^2\cos^2\phi + 2t^2)\cdot(q/n)^3/(6\cdot\cos\phi)$

where L_0 is the central longitude for the map 'zone'.

The accuracy of these formulae, which I have truncated from the full series, is such as to reproduce the latitude and longitude from the grid coordinates with an error of less than 1 metre, or 0".03 (if it were possible to obtain the grid coordinates to that precision). The explicit advantages of this procedure for measuring coordinates are

1. Long-distance uniformity of the measuring scale is not assumed. The longest distance needed to be measured is half the grid line spacing, which probably in all instances is a measurement of less than one inch.
2. Aligning the ruler parallel with the latitude/longitude directions is not as critical as if one measures from the map margins.
3. Dimensional stability in the map becomes a non-problem. The measurements are made from the nearest grid lines; if the location is near a crease, one measures from the nearest grid line on the same side of the crease as the location.
4. Measurement accuracy is improved. In typically used methods, one aligns one end of a ruler with a latitude mark, and measures the distance to the location and to the next latitude mark. That involves the measurement or alignment with three points, and hence three points of measurement error. Measurement from the nearest grid line involves only two points, the scale of the map being used to convert the measurement to a distance in yards or metres.

If anyone is interested, it should be a useful exercise to present appropriate formulae for other datums. As a guide to computational requirements, my HP-67 program occupies 160 steps, of which a fair proportion is for the various constants. Further details should be obtainable from U.S. Army tables TM5-241-32/2.

ERRONEOUS STAR POSITIONS FROM OCCULTATIONS, by David Herald

ZC	SAO	Yr	Mo	Dy	P			Observer	Remarks
	93301	78	Jul	28	R	3	+5	Büttner	HMSO residual +3.7 AGK3 position improves this to +2.5
0680	93981	78	Sep	22	R	3	+4	Hays	ZC R.A. and proper motion in R.A. are too small
	96297	79	Apr	3	D	3	+7	Steicke	AGK/SAO agree
	95318	79	Apr	3	D	2	+4	Steicke	AGK/SAO agree
	96660	79	Sep	13	R	6	-8	Hays	No significant difference between SAO and AGK3
1114	96837	80	Mar	24	D	2	+3	Büttner	SAO, Yale, and AGK3 all agree, and all give a poor residual
	97935	79	Oct	14	R	2	+4	Hays	SAO/AGK agree. Missed R?
0026	109084	78	Dec	8	D	3	+5	Allcott	Poor SAO position in R.A.
	109126	78	Nov	11	D	6	+9	Stockbauer	SAO/GC declination poor; in error by about 1″.8 at 1980
	109611	78	Jan	15	D	2	+5	Blow	Error in early epoch position used for Yale proper motion in R.A.(?)
	110069	78	Dec	10	D	3	+4	Hays	Poor SAO/Yale position in R.A.
	110234	79	Dec	27	D	2	+4	Hays	Poor SAO/Yale. AGK3 good.
1549	118376	78	May	16	D	2	-4	Stocker	SAO/ZC/S70 all agree. Good residual
		78	May	16	D	2	-3	Herdman	
1920	139304	79	Jun	6	D	2	+5	Hays	Yale 1″.1 greater than SAO/GC at 1980
	139607	79	Jul	4	D	4	+7	Stockbauer	P70 gives Dec 1″.5 south of SAO
2035	139794	80	Mar	6	R	6	+11	Stockbauer	SAO and ZC disagree - no Yale position. ZC residual good.
	139956	78	Dec	25	R	4	+14	Blow	Primary of wide double with 139955. First component missed - SAO mag too faint. SAO proper motions for star obtained from unspecified source. Data are consistent with Lick IDS data for the double.
	146032	79	Mar	25	R	2	?4	Steicke	ZC better than SAO/GC.
	158805	78	Aug	11	D	10	+23	Anderson	Near graze. No comparison.
	158835	78	Aug	11	D	8	-12	Anderson	Very poor SAO/GC position - in error by over 3" at 1980
	160254	79	Oct	25	D	3	+6	Hays	No comparison
	160517	78	Mar	20	R	4	-6	Steicke	No comparison
	160785	78	Aug	14	D	6	+13	Anderson	No comparison
2680	161540	78	Oct	8	D	2	+5	Büttner	HMSO residual -1″.8 P70 improves this to -1″.5
2718	161777	79	Apr	18	R	4	-5	Hays	ZC and Yale agree
	161850	78	Oct	9	D	3	+7	Hays	No comparison. Reported also in earlier lists.
2733	161871	79	Jan	26	R	4	-5	Hays	ZC position 0″.5 too far north.
2763	162049	79	Jun	12	R	3	-9	Stockbauer	SAO/GC 2" too small in R.A., cf ZC and Yale
		79	Oct	27	D	4	-6	Hays	
	162262	78	Oct	9	D	3	+4	Blow	S70 position somewhat better than SAO
	162268	78	Oct	9	D	3	+5	Blow	No comparison
	162450	78	Mar	22	R	4	-6	Steicke	No comparison
	162473	78	Mar	22	R	5	-6	Steicke	No comparison
2825	162511	79	Sep	2	D	4	?	Büttner	Yale somewhat north of SAO/GC & ZC. Poor residual for all positions.
	162571	79	Sep	2	D	?	5	Vingerhoets	P70 2″.1 greater in R.A. than SAO
2833	162588	79	May	16	R	6	-8	Hays	SAO/GC 1″.5 too great in R.A., cf ZC. ZC good.
	162707	78	Dec	3	D	2	+4	Allcott	No comparison
2863	162809	79	Sep	3	D	4	+6	Hays	Small difference in declination between SAO, ZC, and Yale. Satisfactory residual.
	163044	78	Nov	6	D	2	+4	Allcott	No comparison
	163363	79	Oct	1	D	4	+8	Hays	No comparison
	164401	78	Nov	8	D	3	+5	Hays	No comparison
	164460	78	Nov	11	D	4	-10	Anderson	No comparison
	164870	78	Nov	8	D	3	+6	Büttner	HMSO residual -1″.6 P70 improves this to -0″.4

ASTEROIDAL OCCULTATION PREDICTION UPDATES

David W. Dunham

(1) Ceres and SAO 60300, 1981 April 21: Arnold Klemola obtained three exposures of Ceres and SAO 60300 on 1981 January 8, when they happened to be only a degree apart. My analysis of these data indicate a 0″.68 south shift of the path and a negligible correction to the time. This path crosses the southern Pacific Ocean, with Tahiti near the center of the path and Samoa near its southern limit. Lowell Observatory and M.I.T. astronomers are considering attempting observations while enroute to the Indian Ocean area for an occultation by Uranus five days later. If they decide to try it, Klemola has measured the positions of 53 reference stars near Ceres' path during the week preceding the event, for possible use by other astrometrists with smaller fields of view who may want to attempt last-minute astrometry. Gordon Taylor also obtained a plate in early January which confirms the south shift. Klemola's prediction is probably accurate to a path half-width or better since the path is so wide, Ceres' orbit is well-determined, and Klemola used AGK3R stars for his plate reduction. A similar early attempt to predict the path for the 1980 October 10 occultation by (216) Kleopatra was not very successful because less-accurate AGK3 data were used for the plate reduction, Kleopatra's orbit is not as accurately known, and the early close approach was greater, 2°. William Penhallow plans to separately check the star positions and ephemerides in advance for three other April events involving (747) Winchester, (91) Aegina, and (94) Aurora, to see if these events might occur in populous areas and warrant more extensive astrometry by Klemola and others.

(129) Antigone and S Scuti, 1981 June 5: My prediction for this event is based on an ephemeris compu-

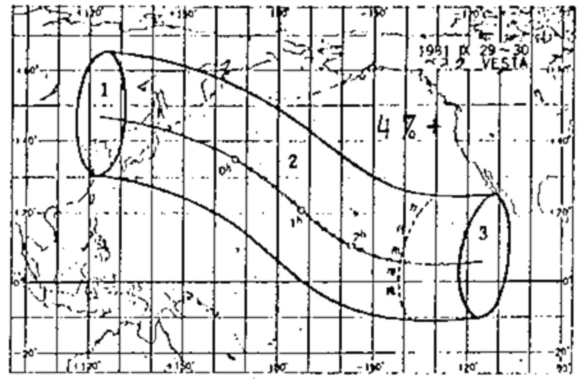
ted from orbital elements published in the Leningrad *Ephemerides of Minor Planets for 1975*. When I did the calculations, I assumed that these would be equivalent to the elements published in the *E.M.P. for 1980*, since no indication of improvement of the orbital elements had been published. However, when I computed a prediction based on an ephemeris calculated from the 1980 elements, I obtained a north shift of 0".84 from my original result, causing the path to miss the Earth's surface by a few hundred kilometers. Hopefully, the actual path will be closer to the original prediction; early astrometry is needed to check this.

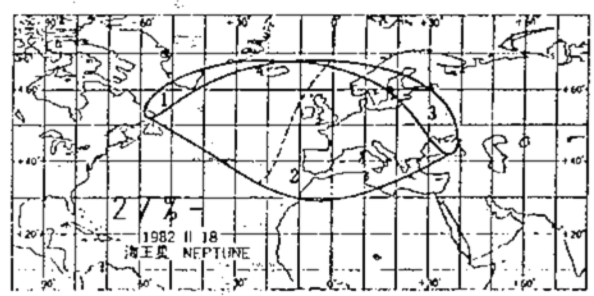
(1685) Toro and SAO 11172, 1981 August 7: Hans Bode and a coworker found this occultation and computed predictions for it using a copy of my prediction program. The 5th-magnitude star is near β Cassiopeiae. If the event had been in my table on p. 116 of the last issue, the values would have been as follows: Aug 7, 3^h29^m, Toro, 14.0, 0.15, 11172, 5.4, B9, $0^h22^m.0$, 61°33', 8.6, 3.5, 44, Mozambique and Tanzania, 93°, 71°, 15-, all. For the second table on p. 117, the values would have been as follows: Aug 7, 1685 Toro, 4.7 (TRIAD diameter), 0".04, 7, S, 3°/day, 42°, 11172, +61° 69, blank, 0.13, 15, 1, 0.2, S, 3 blanks, $0^h23^m.7$, and 61°43'.

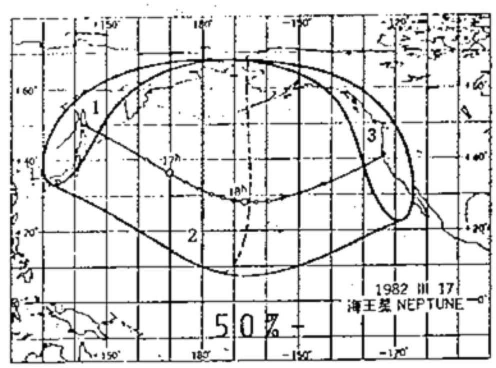
LUNAR OCCULTATIONS OF PLANETS

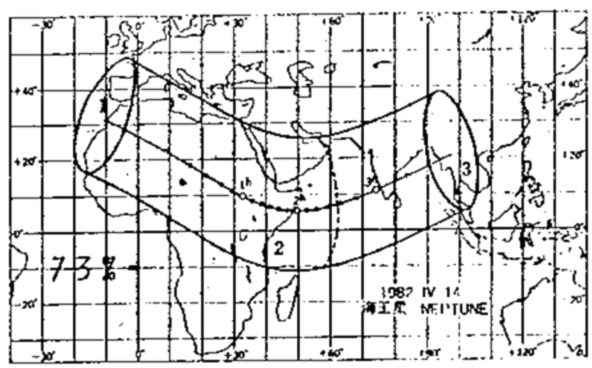
The maps showing the regions of visibility of lunar occultations of planets are reprinted by permission, from the Japanese Ephemeris for 1981 and 1982, published by the Hydrographic Department of the Maritime Safety Agency of Japan. In region 1, only the reappearance is visible; in region 3, only disappearance may be seen. Reappearance occurs at sunset along a dashed curve, while disappearance is at sunrise along a curve of alternating dots and dashes.

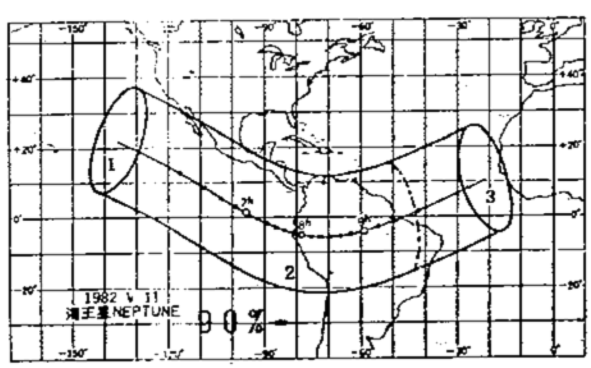
Observers interested in observing partial occultations should request predictions at least three months in advance, from Joseph Senne; P.O. Box 643; Rolla, MO 65401; U.S.A.; telephone 314,364-6233. For further details, see *O.N.* 2 (6), 54-56.

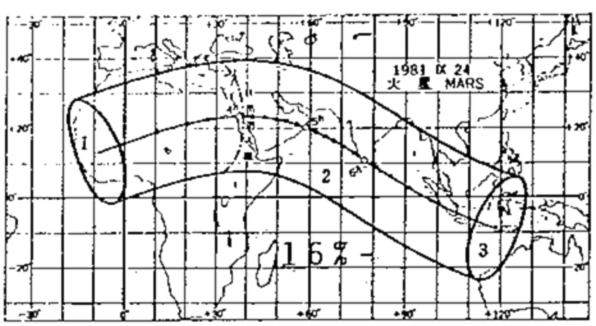


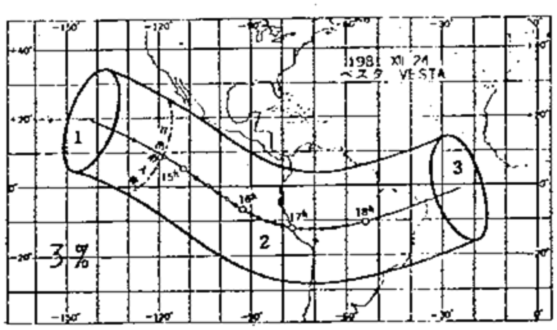






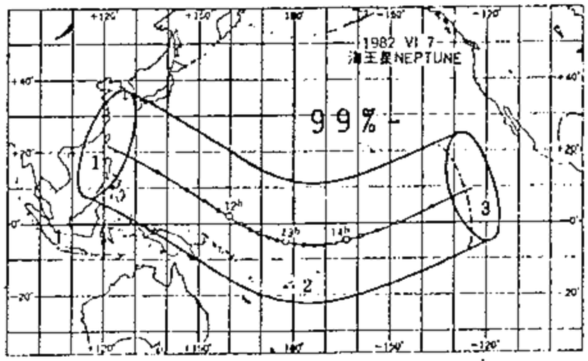


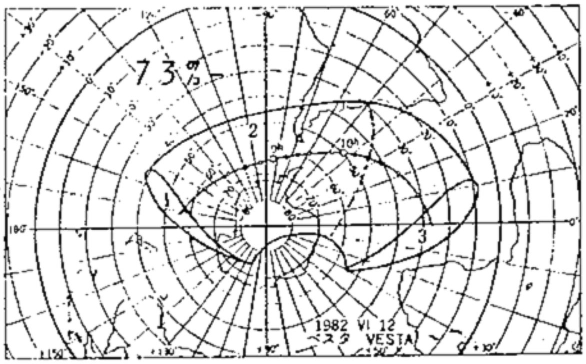


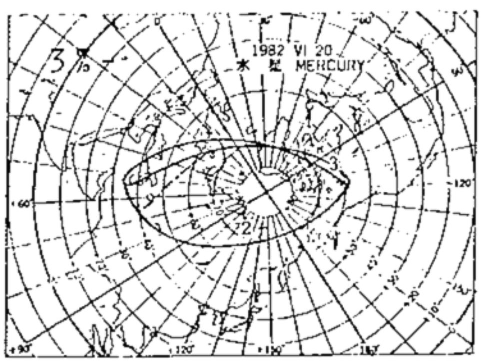


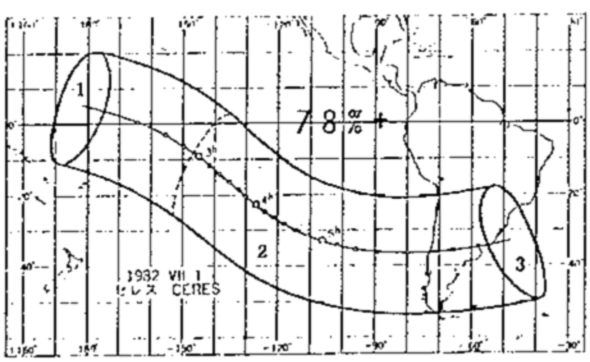
RECENTLY-OBSERVED PLANETARY OCCULTATIONS

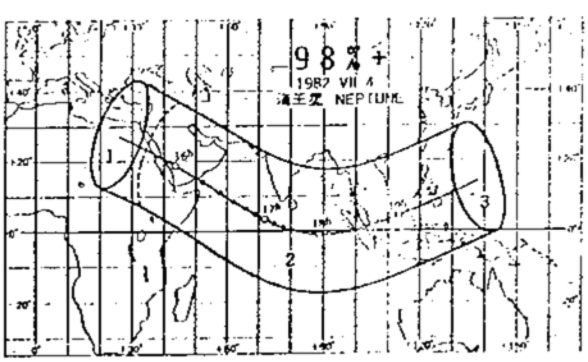
David W. Dunham











Reports of attempts to observe occultations of stars by planets and by asteroids should still be sent to me at P. O. Box 488, Silver Spring, MD 20907, U.S.A. and to Gordon Taylor, H.M. Nautical Almanac Office, Royal Greenwich Observatory, Herstmonceux Castle, Hailsham, Sussex BN27 1RP, England. Gordon Taylor is the chairman of the International Astronomical Union's Working Group on Planetary Occultations, and remains the source for most of the original predictions of these events. Reports of these events should not be sent to the International Occultation Centre in Japan, since they collect only Lunar occultation observations. In some cases, local or regional coordinators will collect all observations from a given area to pass on to us. For some events in North America, Paul Maley, 15807 Brookvilla, Houston, TX 77059, will collect all reports.

Large efforts were made for some asteroidal occultations, such as the ones by (6) Hebe on September 15 (astrometry by Klemola at Lick Observatory indicated a path across Ontario, northern New York, and central New England) and by (12) Victoria on October 26. These plans were foiled by widespread cloud cover. However, for the Hebe event, Mike A'Hearn and Mark Trueblood, travelling from the University of Maryland and using a 14-inch Celestron borrowed from the National Capital Astronomers, went to a site in Algonquin Park, Ontario, near the predicted path center, where skies cleared about two hours before the event. The temperature also dropped sharply, causing heavy dew. The main telescope was protected with heating elements, but the finder was not. Consequently, the star was not located and centered until 10 minutes after the event.

Short accounts of three successfully observed asteroidal occultations in North America during the consecutive months of September, October, and November, 1980, are given below. Additional information is given in the captions to Figures 1 - 5 and in Table 1. Credit for the successes of these events must be shared with Gordon Taylor and Derek Wallentinsen, who initially identified them, and with several others who devoted many hours of work to the astrometry and observational organization which resulted in success, including Arnold Klemola at Lick Observatory and William Penhallow in Rhode Island; Paul Maley and Bill Shoots in Houston, TX; personnel at radio station WWV; Chris Aikman at Dominion Astrophysical Observatory, Victoria, British Columbia; Richard Linkletter of the Olympic Astronomical Society; Bill Hubbard and others at the University of Arizona, and Bob Millis and others at Lowell Observatory; Alan Harris at Jet Propulsion Laboratory; Clay Sherrod running the message center in Arkansas; Jim Van Nuland in San Jose, CA; and many more, including hundreds of observers who tried and many who were clouded out.

(78) Diana and SAO 75392, 1980 September 4: Regional maps for this, and the next two, events were published in the last issue. Preliminary astrometry indicated a path near the AGK3 path, but final results with the objects on the same plate a few days before the event indicated a more eastern track. The eastern edge of the path turned out to be near 0".34 W on the regional map, over the eastern parts

TIAD = TUCSON (REVISED) INDEX OF ASTEROID

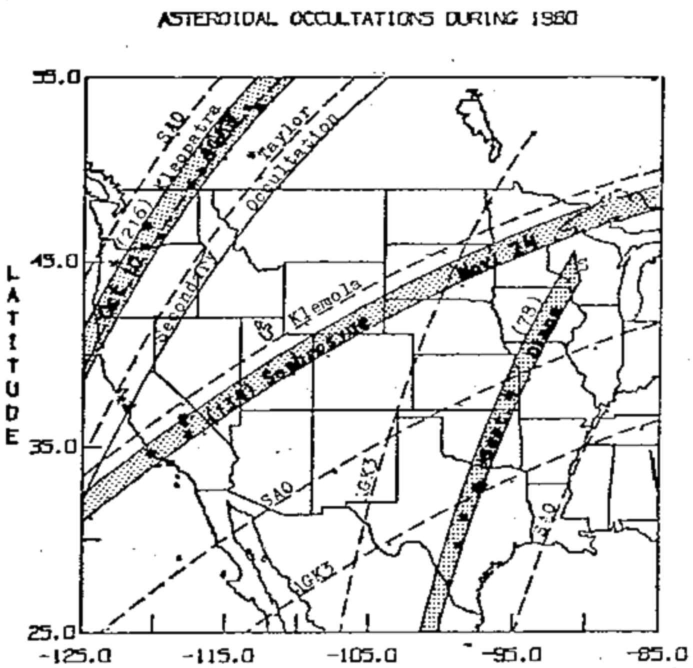


Fig. 1. The shaded bands show the paths of occultations of three stars by asteroids during 1980. Asterisks mark the locations of observers. Dashed lines show the centers of some of the predicted paths. Those marked SAO and AGK3 are preliminary predictions based on the asteroid's nominal ephemeris and on star positions from the respective catalogs. In two cases, paths based on "last-minute" astrometry are shown; see text. For (78) Diana, the path predicted from Klemola's and Penhallow's data was just west of Ft. Worth, TX, 0."03 east of the actual path center; Diana subtended 0."08.

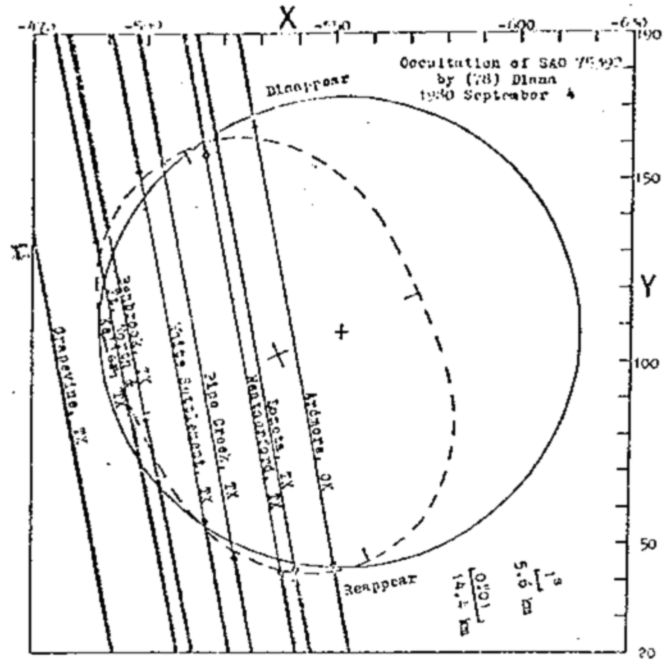


Fig. 2. The observations of the occultation by (78) Diana are shown projected onto the plane of the sky. X and Y are differences in R.A. and Dec. from the nominal prediction multiplied by the observer's distance to the asteroid. The star was visible when the lines are thick and occulted when thin; large dots mark contacts used in the solutions. If the event was either not timed or poorly timed, the line is broken. The size of 0."01 and of 1 second of asteroid motion are shown. All observers were in the eastern half of the path. The trend of the observations seems to favor the circular fit, which is in better agreement with the TIAD diameter of Diana based on indirect measurements. But lightcurve data favor an ellipticity closer to that of the best-fit ellipse, shown in dashes, with a smaller mean radius

of Ft. Worth, TX, while the western edge must have been at about 0.42 W. Ten observers, all in the eastern half of the path in Texas and Oklahoma, recorded the occultation visually; their names and a plot of their observations are presented on p. 397 of the November 1980 issue of *Sky and Telescope* (a finder chart had been published in the August issue). Refined times since the plot was published showed Michael Coucke's observed chord to be lined up well with the others. John Williams observed the reappearance time only at Benbrook, TX, on a chord about a fourth of the way from Garland-Stockbauer's chord to the Dunhams' chord. David McDavid, at Pipe Creek, TX, recorded a chord about a third of the way from the Dunhams to M. Coucke. Six of the observers were in three pairs, with separations within the pairs 7 km or more along the predicted path, to produce at least a 2-sec. time difference. This was done to confirm that the velocity of any secondary occultation matched that of the asteroid, but no secondary events were reported. The paired timings did show that less-experienced observers were slower than those with some Lunar occultation timing experience, even after taking larger estimated reaction times into account, by a few tenths of a second. In two cases, a timing for the disappearance was made, when the observers were distracted by a passing automobile or other cause. They estimated reaction times of about 1.s0, but in each case the true reaction time, according to very close or paired observers, was greater than two seconds and the timings were not used in the analysis. The mean diameter was about 120 km, but this is rather uncertain due to the lack of timings from the western side of the track.

(216) Kleopatra and SAO 128066, 1980 October 10: In the 1980 September issue of *Sky and Telescope,* there is a detailed chart showing the occulted star on p. 213 and an article about Kleopatra's unusual light variations on p. 203; this was followed up by a letter indicating that Kleopatra might be a contact binary in the October issue. Unfortunately, later light-curve data showed that the occultation would occur within 15 minutes of minimum light, so that Kleopatra would be facing nearly end-on, making it impossible to distinguish between a contact binary model or an elongated shape from the observed occultation outline. Unluckily, the two occultations in November occurred only within a few minutes of minimum light, so observations of them also could not distinguish. A prediction based on plates by Klemola showed the path to be 0."29 S of the nominal SAO prediction. During the next couple of nights, Penhallow and Taylor got plates showing the path to be near 0."6 S, passing over northern California. Since these two independent results agreed and were later that Klemola's, we recommended that portable

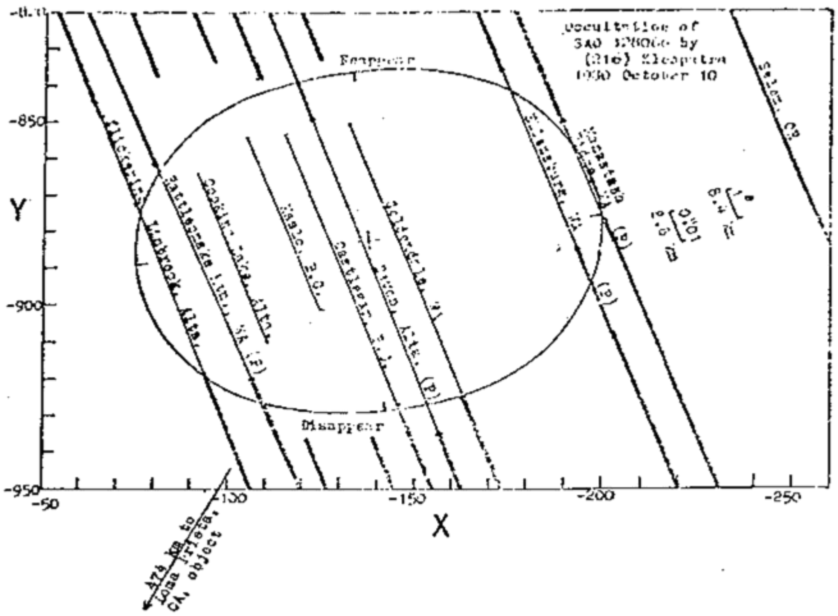


Fig. 3. This is similar to Fig. 2, but for the occultation by (216) Kleopatra. Photoelectric observations are identified with "(P)." Deviations from the best-fit ellipse are due more to irregularities of the asteroid than to timing errors. Some data for visual observers are incomplete, especially for the group at Cooking Lake, but I don't expect any significant change when the data are finalized.

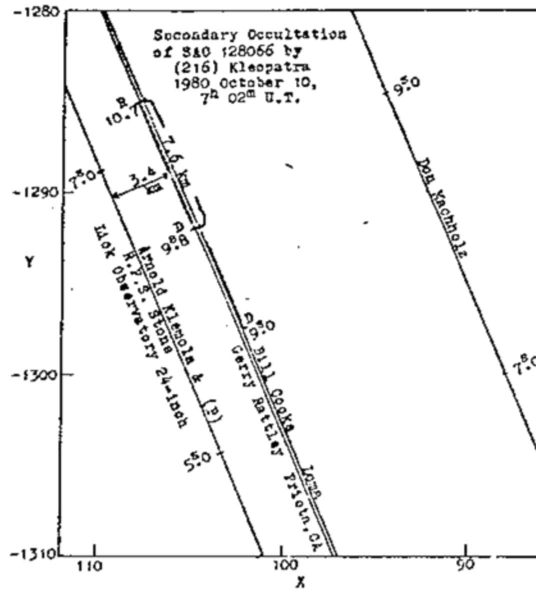


Fig. 4. This is like Fig. 2, with expanded scale, showing the secondary extinction observations made from Loma Prieta, CA. Seconds past 7^h02^m U.T. are shown along the tracks. Both Loma Prieta observers timed only the D, and Cooke did not notice the R. Rattley's estimated duration is probably good to ± 0ˢ2. The 0ˢ8 absolute timing difference can be due to the observers' relative inexperience in timing occultations.

observers go to the eastern track, and mobilized the Californian observers. But Klemola's prediction was closest, only 0".06 in error and just within the actual path, whose edges were at 0".15 S and 0".31 S. Klemola's field of view, about 3°5 wide, included more reference stars than the narrower fields of the others, and reference stars in that part of the sky are rather sparse. Klemola saw that some of the reference stars in one part of his field had positions which did not agree very well with his measurements, so he did not use them for his overall plate solution to determine the local reference frame. With the smaller fields, the others did not know this, so the systematically bad stars on the one side of their fields skewed their reference frame, resulting in the bad prediction. But as Chris Aikman points out, the actual path was lucky in that it included the largest possible number of fixed observatories, and photoelectric records of the occultation were made at four of them. Visual timings were made at five other stations in Alberta, British Columbia, and Washington.

A secondary occultation of about 0ˢ9 duration was simultaneously recorded by Gerry Rattley and Bill Cooke at sites about 2000 feet apart at Loma Prieta, CA. Their observation is about 475 km from Kleopatra in the plane of the sky. The photoelectrically determined magnitude drop was about 1.2 for an occultation, and visual observers of the main occultation felt that the color change which occurred when the orange spectral-type K star disappeared, leaving the relatively bluish asteroid visible, was more remarkable than the light intensity change. Rattley and Cooke reported the same phenomenon before they knew of any other observations of the event. Lick Observatory was 3.4 km east of their path, and A. Klemola and R.P.S. Stone recorded no variations in a photoelectric record made with a 24-inch reflector. It is possible that nothing happened there, since the estimated chord length of the Loma Prieta event was 7.6 km, and if the center of a roughly circular object passed only a little to their west, no secondary event would occur at the Lick telescope.

Astrometry by Penhallow showed the path for the November 21st occultation by Kleopatra to be at about 0".6 north, over northern Brazil and Colombia. Clouds prevented observation from all parts of Brazil. For observers in Chile, the asteroid was seen to pass north of the star, while for those in the USA, it was seen to pass to the south.

(134) Sophrosyne and SAO 74963, 1980 November 24: Paul Maley has written a comprehensive report of the efforts to observe this event, the most extensive for any asteroid occultation to date. Part of his report will be published in a future issue. Early astrometry by Taylor in late October indicated that the path would be far to the north of the SAO and AGK3 tracks, at about 0".7 N on the regional map published on p. 396 of Maley's article in the November issue of *Sky and Telescope*, which also contained a finder chart. The only "last-minute" astrometry for the occultation were three exposures by Klemola six days before the event, indicating a path at 0".84 N, but with some scatter in the individual measures. This prediction was broadcast on WWV during the fourth minute after each hour starting at 0^h U.T. November 22 and continuing until shortly after the occultation. The arrangement with WWV is that they are willing to do this on a free basis once or twice a year, but it will be necessary to pay for the service if it is done more frequently. That is why

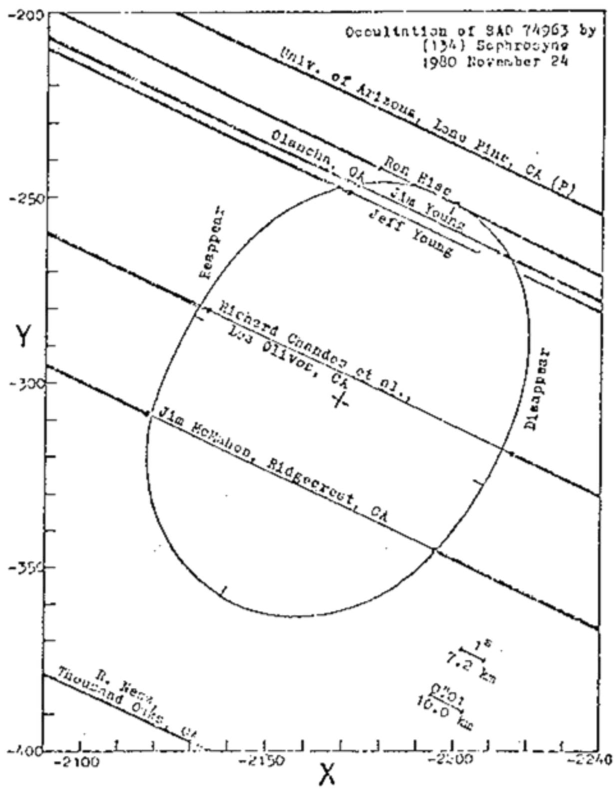


Fig. 5. This is similar to Fig. 3, but for the occultation by (134) Sophrosyne. As far as I know, the data are final.

there were no broadcasts for some of the other late 1980 asteroidal occultations. The announcements on WWV proved very useful for informing large numbers of observers about the location of the predicted path. The Asteroid Intercept Radio Net was also valuable for coordinating observational coverage over a large area, and regional ham radio nets using different frequencies for different areas at different times of the year are planned for future events.

Considering Klemola's good astrometric record for predicting previous asteroidal occultations, we felt that his prediction for Sophrosyne would be accurate to ±0"06 (60 km) or one predicted Sophrosyne radius. So most mobile observers concentrated their efforts in a band 240 km wide centered at 0"84 N. The actual path center was about 0"14 south of this prediction; hence, only three observers in the southern end of the prime zone, all north of Olancha, CA near Owens Lake, observed short occultations defining the northern limit quite well. They were Ron Hise, Jim Young, and Jeff Young. Richard Chandros and others from Santa Barbara timed a nearly central event at Los Olivos, CA, and Jim McMahon, observing from the China Lake Astronomical Society's observatory in Ridgecrest, CA, defined a chord south of the asteroid's center. There was patchy cloudiness in California, and several others within the actual path were clouded out. Sophrosyne appeared to be quite elongated in the north-south direction, with a mean diameter near 110 km.

Extensive cloud cover prevented observation for secondary occultations from most other parts of the U.S.A., but even so, rather good coverage was provided for a distance of 435 km north and 675 km south of the actual path. Three reports of possible secondary events were not confirmed by the other observers of each pair in question at the same distance from the path. Gordon Taylor reports that the British Astronomical Association had planned an expedition to southwestern France, but cancelled due to poor weather prospects. The actual path included the Pyrenees Mountains, but no observations were made at Pic du Midi Observatory. The southern limit must have passed near Barcelona, Spain, but we have not heard from occultation observers there.

More astrometry would have improved the statistics, and probably the final prediction, for this event. But weather prevented more attempts by those now doing this work. Klemola and I believe that the predictions can be improved by using 17-inch (6° field) plates at Lick and reducing the measures with AGK3R data (more accurate data available for approximately one star per square degree) to define the best possible reference system. Faint non-catalog stars will be measured near the path of the asteroid, so that other astrometrists with smaller fields of view can use these derived positions to reduce their plates. Since this secondary net will be referred well to the occulted star, the other observatories can get useful astrometry earlier than before, so that more astrometric data should become available to improve future asteroidal occultation path predictions. Hopefully, this will keep final prediction errors rather consistently under 0"1 for the most important occultations which we plan to try.

The results of analysis of the timings of this occultation, as well as those by (78) Diana and by (134) Sophrosyne, are given in Table 1. Five figures illustrate these three 1980 occultations.

Neptune and SAO 185377, 1980 November 24: Plates exposed by Klemola at Lick Observatory on August 12 indicated that the southern limit of the occultation crossed Indonesia. A close appulse might have been seen from South Australia, but even there, conditions were so marginal that visual observations probably would have been impossible. I received two inquiries from Australian observers, and had hoped to publish this result in an issue of *O.N.* before the event, but my schedule was too tight to do this. According to *I.A.U. Circular* No. 3515, P. Nicholson and T. Jones photoelectrically recorded the emersion of Klemola's star 23 on 1980 August 21 at U.T. $12^h49^m47^s \pm 5^s$; it was accompanied by at least ten sharp spikes. A possible secondary occultation $1^s.5$ long with depth 0.7 was reported about 1.5 Neptune radii away in the equatorial plane. The August 15 appulse to star 22 was also monitored, with no occultations. An occultation of Klemola's star 12 by Uranus and its rings on 1980 August 15 was very successfully observed from the European Southern, Las Campanas, and Cerro Tololo Observatories in Chile, according to *I.A.U. Circular* No. 3503 and 3515. Analysis of the 1980 March 20 occultation by Uranus' rings is reported by J. Elliot *et al.* in *The Astronomical Journal 86* (2) 127, 1981 January. From all available ring occultation data, they derive a value for Uranus' dynamical oblateness factor $J_2 = (3.396 \pm 0.020) \times 10^{-3}$ and they estimate the mass of the β ring to be about 4×10^{16} grams. Articles in the same *Astron. J.* issue by A. Klemola, D. Mink, and J. Elliot give information about predicted occultations by Uranus and Neptune for 1981 -

1984.

(739) Mandeville and SAO ?, 1980 December 10: Toshio Hirose informed me that this occultation, previously unknown to me, was successfully observed from Japan. I have not computed an ephemeris to identify the star, whose number was not reported; I don't know anything more about the event.

Jupiter and SAO 138820, 1980 December 11: Doug Mink, M.I.T., reports that observations of this event were generally unsuccessful. Since the ring was not detected, only an upper limit could be assigned to its optical thickness. Immersion and emersion by Jupiter were recorded at Kitt Peak National Observatory, but the photoelectric data seem to be too noisy to obtain useful information. Apparently, only occultations of stars brighter than mag. 8.6 by Jupiter can yield useful data.

(44) Nysa and SAO 119165, 1981 January 8: Jean Pinson reports that he and B. Candela, using 21-cm telescopes, observed this occultation from La Seyne, France (near Marseille). This makes the fifth asteroidal occultation observed during five consequetive months. The combined light dropped abruptly by 1.5 magnitudes at $2^{h}13^{m}02\overset{s}{.}7$ U.T. and remained at this low level for 8 to 12 seconds. Then flickering was seen for several seconds until $2^{h}13^{m}21\overset{s}{.}2$, after which the combined image remained steady at its original brilliance. The occultation occurred two minutes later than my prediction at a path of $0\overset{''}{.}24$ north on the world map published in the last issue and on regional maps sent to several potential observers. Unfortunately, I know of no other reports which would be needed to determine Nysa's outline. Rapid flickering after reappearance has been reported during two other occultations with Δm's slightly greater than 1.0, by some visual observers. The first was the occultation by (18) Melpomene on 1978 December 11 and the other was the October occultation by (216) Kleopatra, see Fig. 3, path for Linbrook, Alberta. In fact, most of the visual observers of both the primary and secondary occultations by Kleopatra reported this phenomenon, in some cases so severe that, as for the Nysa event, the emersion could not be accurately timed. Using a 25-cm reflector, I did not notice any flickering after the reappearance from behind Melpomene, and no such phenomena were recorded at the several photoelectric observatories for Melpomene and Kleopatra. Richard Linkletter has suggested that the phenomenon may be psychological, perhaps an unconscious variation in the eye induced by the excitement of seeing the disappearance. Combined visual and photoelectric observation of future events with similar magnitude drops may shed more light on the situation.

(365) Corduba and SAO 111635, 1981 January 26: Astrometry by Klemola on Jan. 20 showed that the event would occur $7\overset{m}{.}6$ early on a path $3\overset{''}{.}3$ south of the nominal prediction, shifting the path well south of North America into the South Pacific near Pitcairn Is. Klemola measured the positions of 70 faint stars near Corduba's path and relayed these to Randy Olsen at New Mexico State University, where astrometric observations of Corduba were made with a 24-inch reflector with 30' field. Reduction of their measures with Klemola's reference stars confirmed the large south shift, demonstrating the utility of Klemola's secondary net, although the occultation itself was not accessible. Some observers in California monitored the appulse and reported no events, as expected. Earlier plans to disseminate the shift information by the Asteroid Intercept Radio Net were not carried out. Some early astrometry could have detected the large ephemeris error and saved some of the last-minute efforts. The error is so large that Gordon Taylor's searches for occultations by Corduba are probably not complete, with some events predicted to narrowly miss the Earth possibly actually occurring in astronomically populated areas.

Table 1. Results of Observations of 1980 Asteroidal Occultations. Both elliptical and circular solutions are shown. For elliptical fits, the mean radius is given, and the flattening is the mean radius minus the semi-minor axis. The radii from TRIAD are based on indirect infrared or polarimetric data. The TRIAD value for Kleopatra is known to be in error; recent indirect measurements agree well with our mean radius.

Asteroid and Date	No. of Contacts	Mean Residual	Radius, km	Flattening, km	Pos. Angle Minor Axis	TRIAD Radius
(78) Diana	14	3.0 km	64.0 ± 2.8			70 km
September 4	14	1.4	51.3 ± 2.1	10.3 ± 1.6	114°1 ± 4°1	
(216) Kleopatra	12	3.7	54.4 ± 1.9	7.9 ± 2.7	6.6 ± 9.1	110
October 10	12	5.4	55.8 ± 2.4			
(134) Sophrosyne	9	1.8	53.3 ± 2.3	8.1 ± 3.8	59.5 ± 6.6	58
November 24	9	3.1	50.9 ± 1.9			

MORE ON ASTEROIDAL SATELLITES

David W. Dunham

Speckle interferometric observations indicating probable satellites of (2) Pallas and (12) Victoria were reported on p. 102 of the last issue. More details were presented at last October's meeting of the American Astronomical Society's Division for Planetary Sciences in Tucson, AZ, and published in *Science News 118* (19) p. 295, 1980 November 8. Pallas' satellite's diameter is estimated to be 175 ±20 km, at a distance of 750 ±100 km, while the distance of Victoria's satellite, whose size has not been determined, is about 330 ±10 km.

A good article, "Do Asteroids Have Moons," was published by Ray Villard in *Star and Sky 2* (9) p. 17 - 24, 1980 September. The only errors I found were the labels on the picture on p. 19 (Herculia should be Herculina, Paces should be Pales, and 24 Hektor should be 624 Hektor), and the statement that the secondary occultation reported for the occultation by (65) Cybele on 1979 October 17 was observed at three stations. That statement is true for Cybele itself, but only one of the visual observers reported the secondary occultation.

In a letter on p. 372 of the 1980 November issue of *Sky and Telescope,* Jack MacConnell casts doubt on the observation of the secondary occultation of SAO 80950 by (9) Metis at Barquisimeto, Venezuela, on 1979 December 11, saying that three other observers who reported no events were "lying along nearly the same occultation track." But as I pointed out on p. 103 of the last issue, the closest of these observers was still 51 km from the Barquisimeto path, considerably more than the radius of a presumed spherical satellite which caused a central occultation of the length observed at Barquisimeto. MacConnell had sent his letter to *Sky and Telescope* before I talked with him last June, when he was also not aware of Juana Ines Chiossone's letter to Paul Maley stating that the disappearance and reappearance were instantaneous and that other stars in the field of view did not vary in brightness during the occultation; see *O.N. 2* (8) 87. The best seeing disks that MacConnell reported for his direct observations of Metis were 1", larger than the observed separation of the Barquisimeto "satellite" from Metis. I believe that the Barquisimeto observation stands as one of the "well-documented" (not my original words) secondary occultations mentioned in my article on 1981 planetary occultations in the 1981 January issue of *Sky and Telescope.* See p. 123 for an article about possible direct observations of the Barquisimeto satellite.

On pages 297-298 of the 1981 January 16th issue of *Science*, Thomas Van Flandern has published a Technical Note answering the questions about minor planet satellite observations raised by Harold Reitsema in *Science 205*, p. 185 (1979). In a late update, he managed to publish, for the first time, the fact that a secondary extinction was confirmed at two separate stations during the 1980 October 10 (Van Flandern incorrectly gave the date as November 10) by (216) Kleopatra. To further publicize the subject, Paul Maley has published an article, "In Search of Satellites of Minor Planets," in *Journal of the Royal Astronomical Society of Canada, 74* (6) 327 (1980).

My letter in response to the article about the 1979 December 11 occultation by (3) Juno in the 1980 April issue of *Sky and Telescope* has been published on p. 126 of the 1981 February issue of that magazine. At one point, I am incorrectly quoted as saying "Several experienced persons obtained visual timings" of the event, while in fact I said "a few visual timings were obtained by a couple of experienced occultation observers." The occultation is more fully discussed in *O.N. 2* (7) 76, (8) 87, and (9) 103. The observations of the event by University of Arizona and University of Hawaii personnel are discussed by Reitsema *et al.* in a good article in *The Astronomical Journal 86* (1) 121 (1981 January). They stress the value of photoelectric observations of asteroidal occultations for measuring the angular diameters of stars not accessible to Lunar occultations. A comprehensive analysis of all of the observations of the event by R. L. Millis and 37 coauthors will appear in a future issue of *Astron. J.*

I have been asked a few times about the length of time before and after the predicted time of closest approach that observation should be made for possible secondary occultations by satellites. Van Flandern has calculated that the sphere of influence for asteroids have radii typically 100 times the diameter, so that observing for 100 times the central predicted duration before and after will fully cover the possibilities. But this is often a very long time; it is difficult for visual observers to effectively concentrate for more than 30 minutes. In fact, observed secondary extinctions have all occurred within 30 diameters (and all sizeable ones within 10 diameters) of the asteroid, so I recommend observing for 2 minutes (to take into account possible error in the predicted time) + 30 times the predicted central duration before the predicted time, to a similar amount after it. For example, if the predicted central duration is 20 seconds, the total observing time should be 24 minutes centered on the predicted time. For very long duration events, I would recommend not observing for more than 30 minutes (unless extra observers are available), but do cover 10 times the central duration before and after. Be sure to pay carefullest attention during the five-minute interval centered on the predicted time.

PLANETARY OCCULTATION PREDICTIONS (Continued)

David W. Dunham

June 7: SAO 98622 may be a close double, with component magnitudes of 9.1 and 9.6, separation about 0".4 in direction 158°, based on Jim Van Nuland's observation of a Lunar occultation on 1979 June 1; see *O.N. 2* (7) 71.

June 21: Derek Wallentinsen's predicted occultation of SAO 119142 by (44) Nysa is not included since it will occur in the far South Pacific Ocean where there are no islands.

Aug 7: Photoelectric observations will be needed to reliably detect the small magnitude drop during this event, as well as for other asteroidal occultations listed in the table with Δm's smaller than about 1.0. Only experienced occultation observers have detected drops in the range of 0.4 to 1.0 mag. when atmospheric seeing was good. A large satellite of (18) Melpomene is suspected from an observation of the 1978 December 11 occultation. Melpomene is unusually close during the perihelic opposition in August, so circumstances for detecting the satellite by speckle interferometry or perhaps even by direct observation (elongations may significantly exceed 1".0) are unusually favorable. The close approach also magnifies small uncertainties in the orbital elements, leading to a rather large uncertainty in the position of the path. This could be considerably reduced by astrometric observations a month or two before the event.

Aug 11: Gordon Taylor's predicted occultation of SAO 78260 by (83) Beatrix is not included since it will occur in island-less parts of the Indian Ocean.

Aug 26: SAO 77350 is Z.C. 849; a "gradual" disappearance reported at a 1935 lunar occultation indicates possible duplicity.

Aug 27: It is not known whether the path for this occultation will cross western Europe, only the North Atlantic Ocean, or eastern North America due to large uncertainties in both the ephemeris and the star's position. The path runs steeply from north to south. The prediction can be considerably improved by astrometry a couple of months in advance.

Sep 4: See note for Aug 7 above.

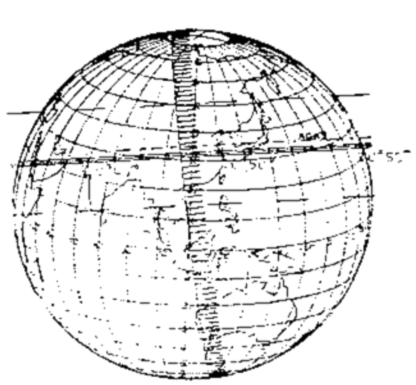
Sep 12: Jean Meeus points out that Uranus will pass 7" north of 5.5-mag. 41 Librae around 19^h37^m U.T. There will be no occultation by Uranus or by its known rings or satellites, but possible material in the known satellite orbits might briefly dim the star for those in western Europe or in Africa.

Nov 2: The star has an 11th-mag. companion 47" away in p.a. 338°, too far away to be occulted by Thisbe.

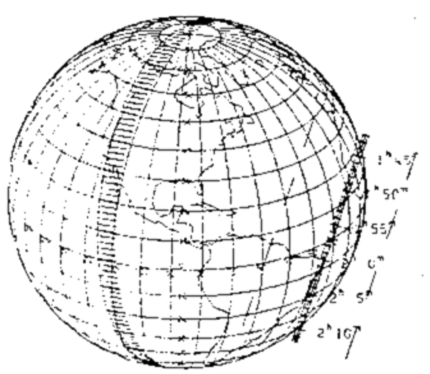
Nov 28, (624) Hektor: This Trojan asteroid is probably two objects crushed together. A southward shift of the uncertain predicted path will be needed to make the occultation visible from somewhere in a narrow band crossing the U.S.A. The southern declination and 36° elongation from the sun will hinder observation and prevent an accurate astrometric update. Even the longitude of the narrow zone of possible viewing is uncertain due to the large difference in time predicted by the two available orbits. This uncertainty could be eliminated by astrometric plates taken at opposition in June, but these must be taken at a Southern-Hemisphere observatory since the declination then will be -44°.

1981 Dec 30: The occulting object is the *asteroid* 106 Dione, not Saturn's satellite of the same name.

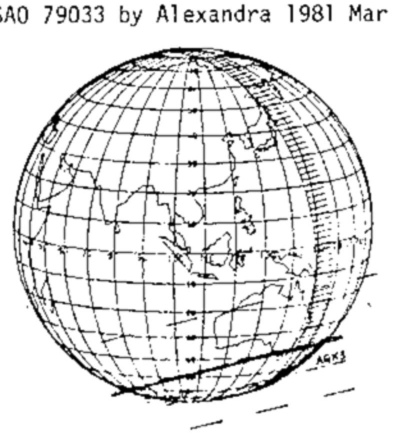
1983 May 29: Data for this event are not in the current table, but were included in the tables in *O.N.* 2 (7) 64-65. Predictions based on several available star positions were described in *O.N.* 2 (9) 111. These are shown on the regional map for the event in this issue. In his Bulletin 25, Gordon



SAO 94045 by Arethusa 1981 Feb 26



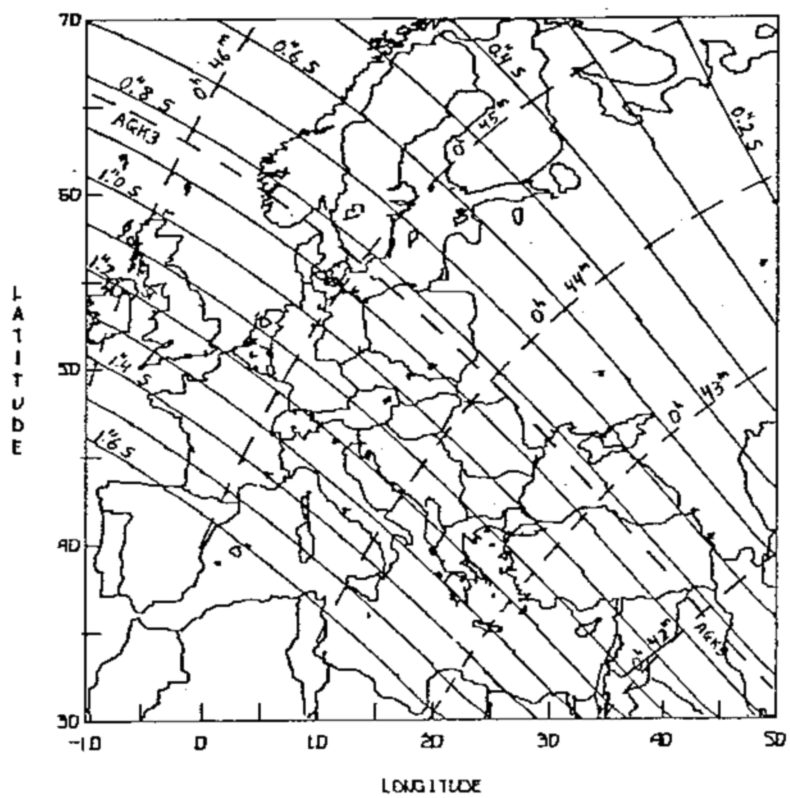
SAO 79033 by Alexandra 1981 Mar 6

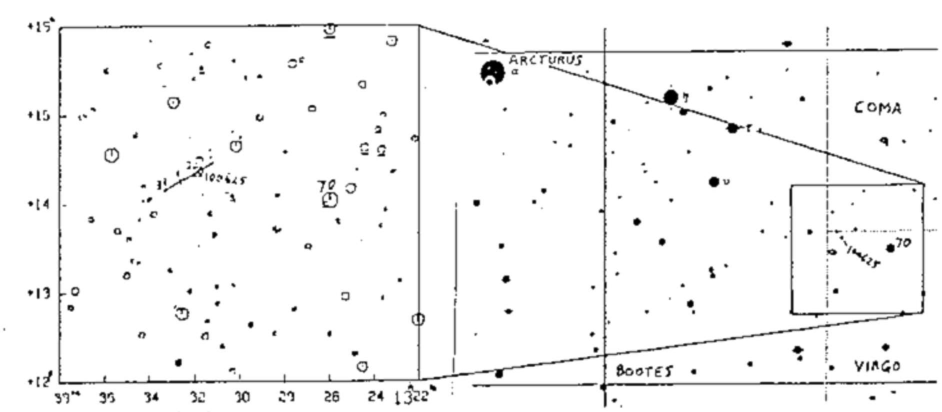


SAO 110447 by Kleopatra 1981 Mar 6

1981 4 2 (747) WINCHESTER SAO 100625

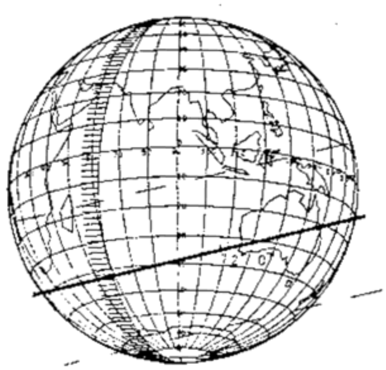
DIAMETER 208 KM - 0."10





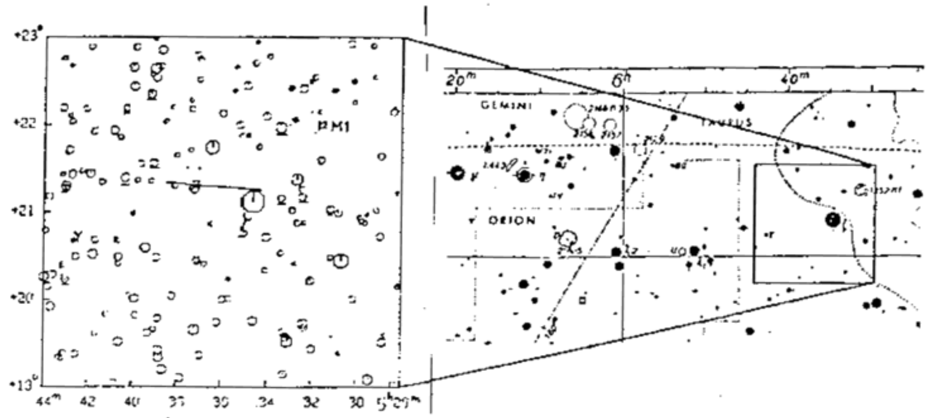
1981 APR 2 (747) WINCHESTER SAO 100625

Taylor tells of communication about this with the Astronomisches Rechen Institut in Heidelberg, German Federal Republic. They noted that the FK4S position is preferable to that given in the AGK3. A position for the S.R.S. program obtained in 1969 at El Leoncito, Argentina, agrees best with the southernmost path predicted by the SAO (G.C.) position, but the G.C. is considered to be one of the poorer catalogs, and 1 Vulpeculae's altitude at culmination is relatively low at the latitude of El Leoncito. Once the star position problem is resolved, perhaps with the help of a diffraction grating for comparison with Pallas a week or so before the event, we can try to predict the path of occultation by Pallas' large satellite, which should be possible with an orbit determined from speckle interferometric observations.

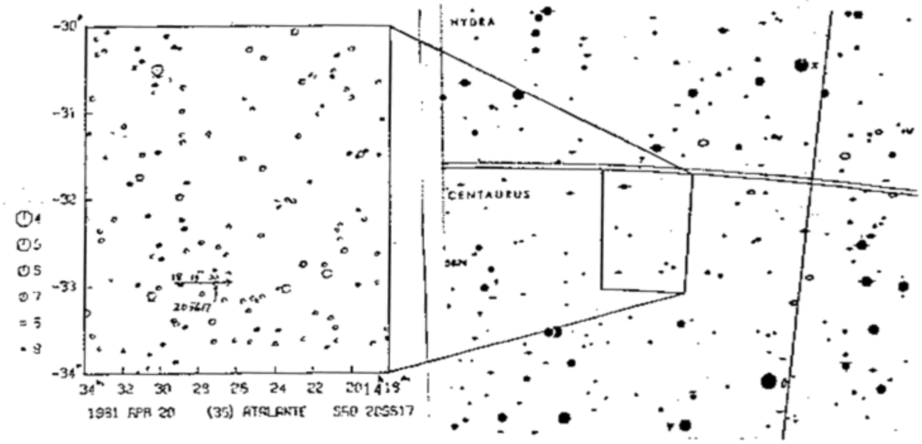


SAO 162369 by Hesperia 1981 Mar 9

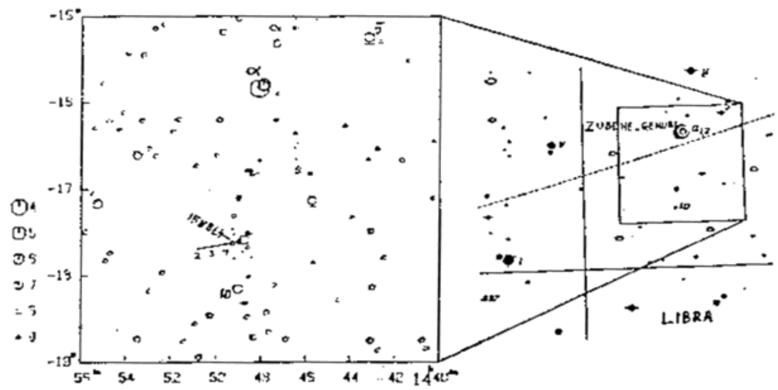
[The world maps are produced by Mitsuru Sôma, the regional maps by David Dunham.]



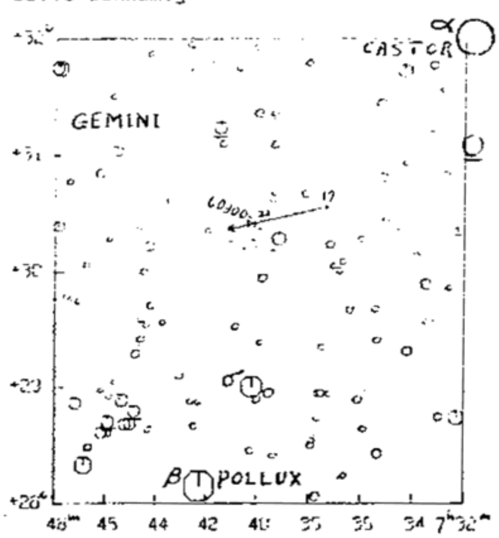
1981 APR 15 (15) PSYCHE SAO 77370



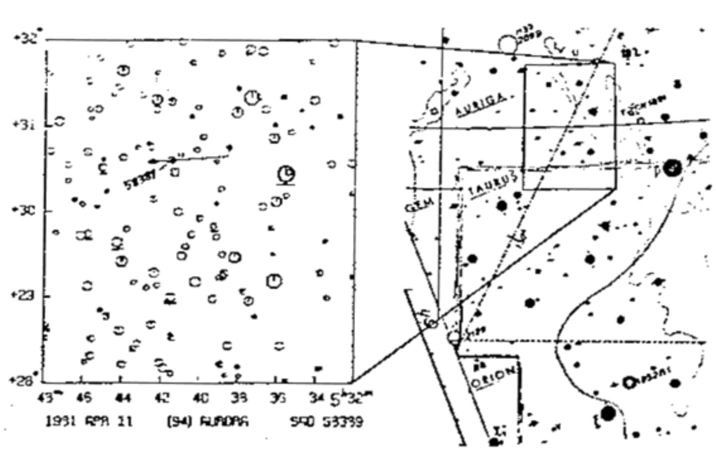
1981 APR 20 (35) ATALANTE SAO 205517



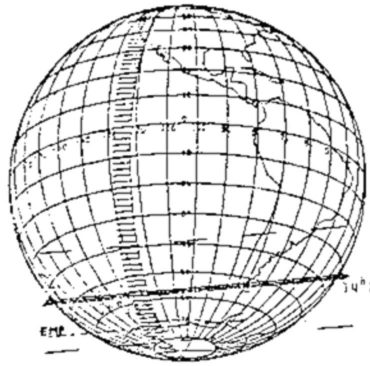
1981 APR 4 (31) REGINA SAO 158394



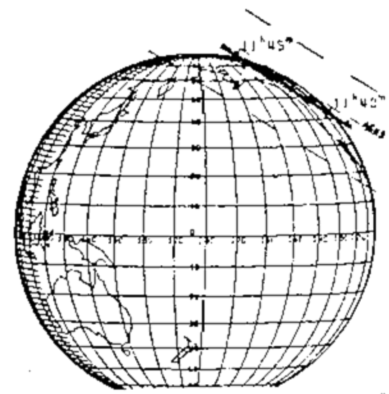
1981 APR 21 (1) CERES SAO 60300



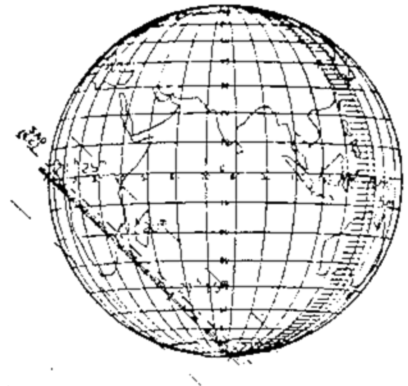
1981 APR 21 (94) AURORA SAO 58339



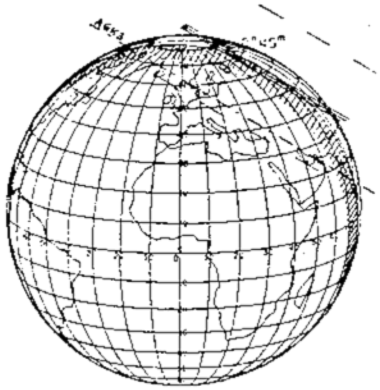
SAO 161895 by Parthenope 81 Mar 13



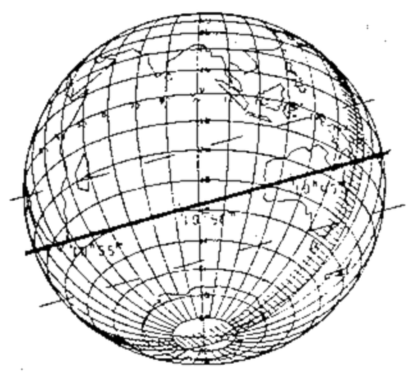
SAO 118832 by Doris 1981 Mar 19



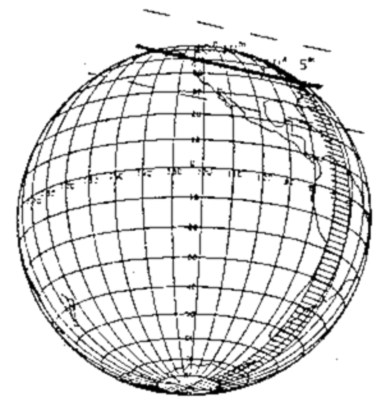
SAO 139976 by Laetitia 1981 Mar 25



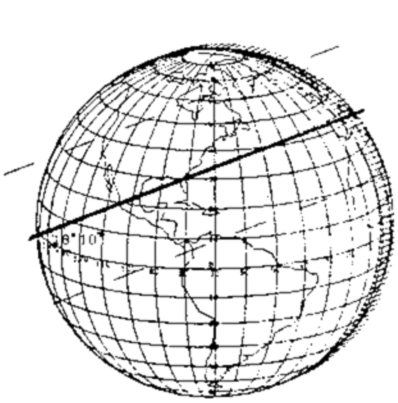
SAO 100625 by Winchester '81 Apr 2



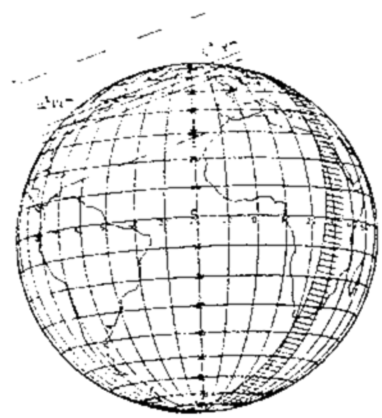
SAO 205907 by Atalante 1981 Apr 2



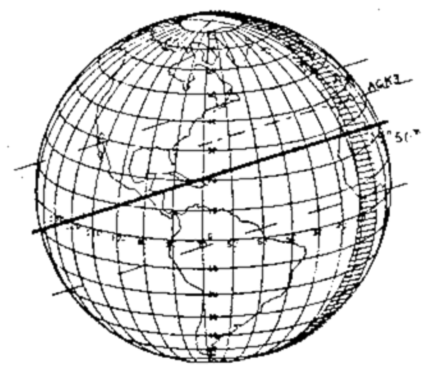
SAO 158864 by Aegina 1981 Apr 4



SAO 92925 by Beatrix 1981 Apr 4

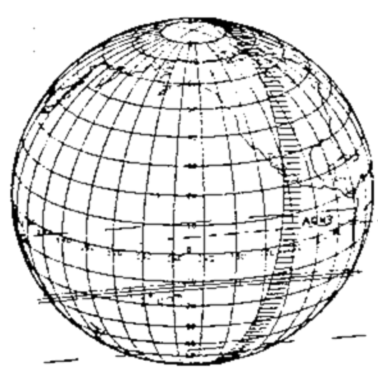


SAO 130921 by Pallas 1981 Apr 7

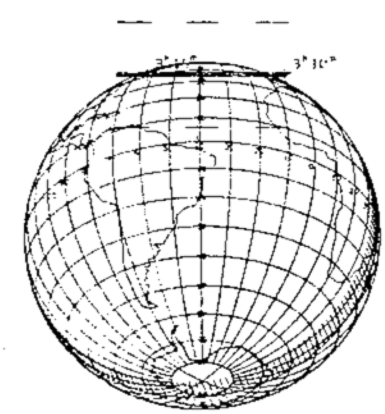


SAO 93474 by Semele 1981 Apr 8

SAO 58389 by Aurora 1981 Apr 11

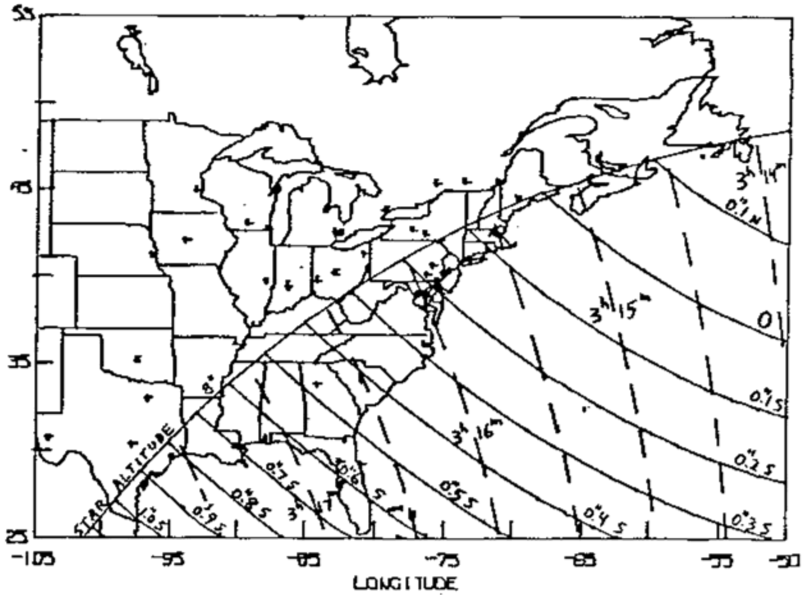


SAO 77370 by Psyche 1981 Apr 15

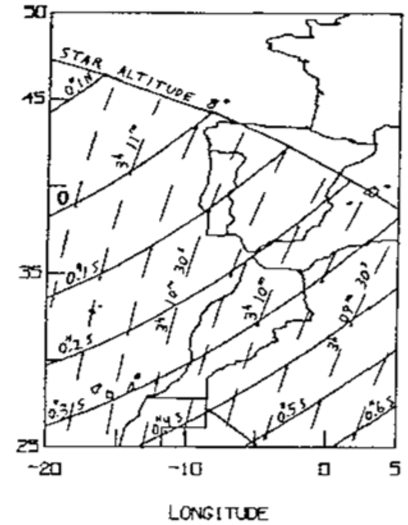


SAO 205617 by Atalante 1981 Apr 20

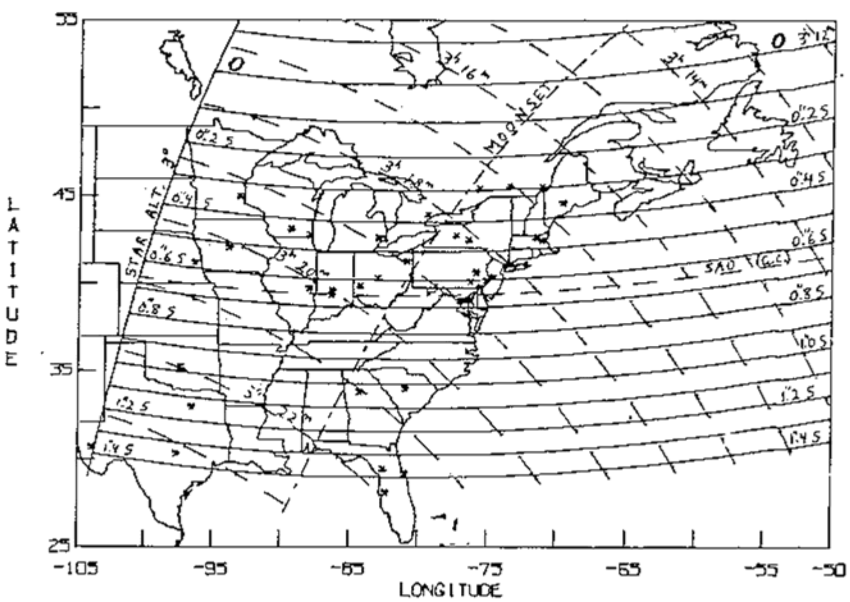
1981 4 20 (36) ATALANTE SAO 205617
DIAMETER 124 KM = 0."06



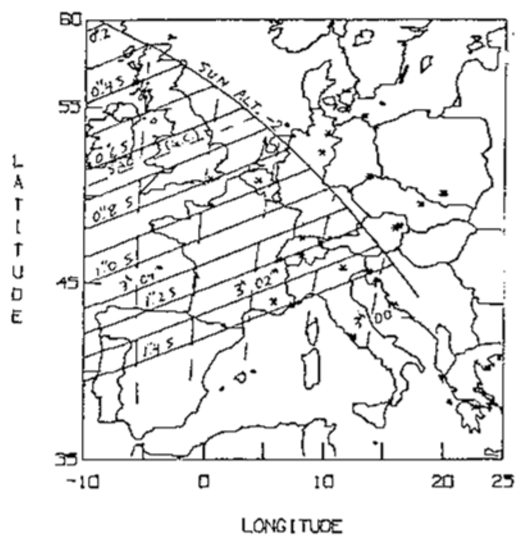
1981 4 20 (36) ATALANTE SAO 205617
DIAMETER 124 KM = 0."06

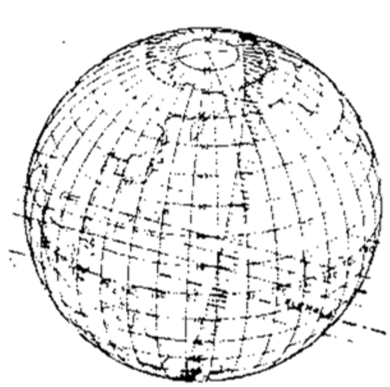


1981 6 5 (129) ANTIGONE SAO 142674
DIAMETER 113 KM = 0."11

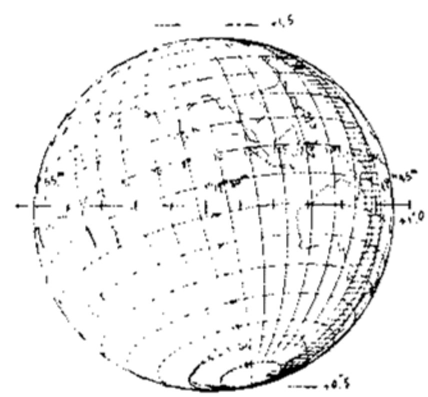


1981 6 5 (129) ANTIGONE SAO 142674
DIAMETER 113 KM = 0."11

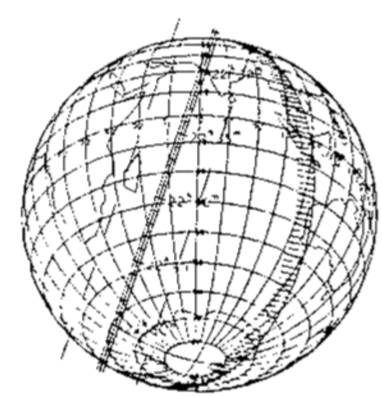




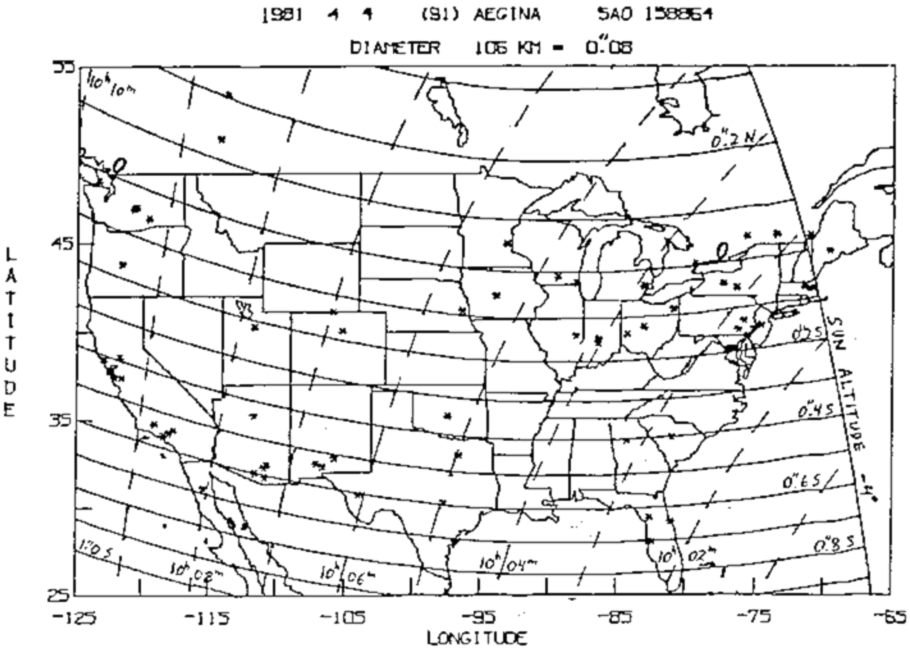
SAO 60300 by Ceres 1981 Apr 21

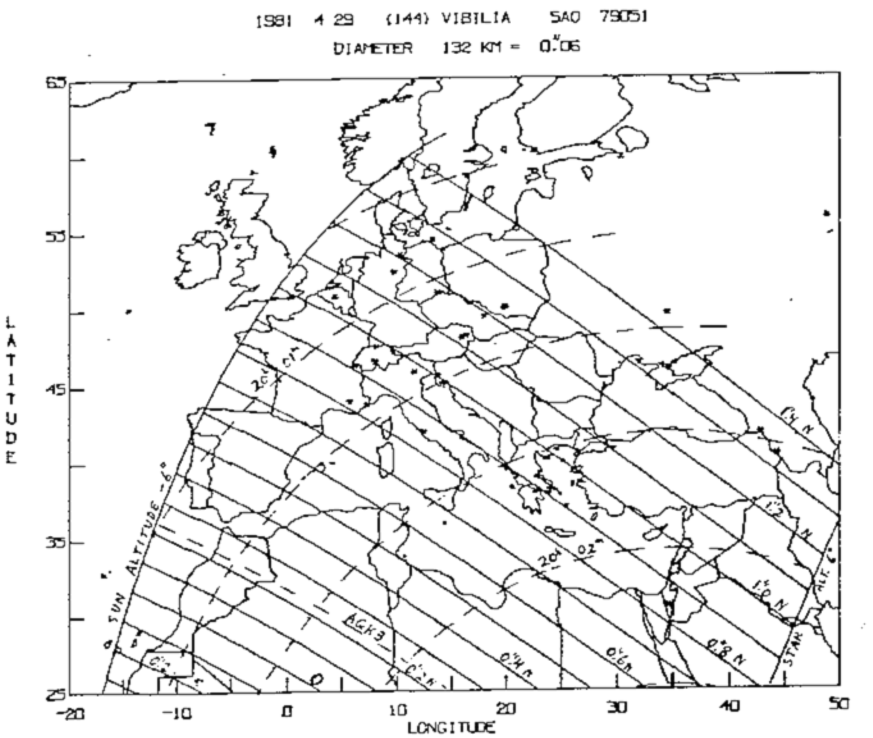


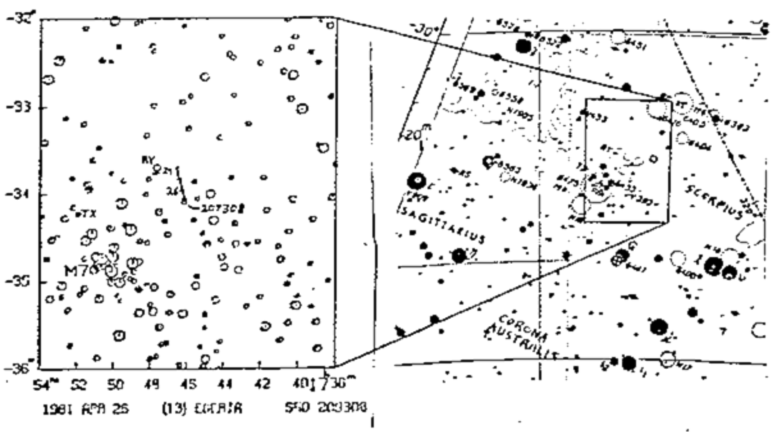
-19° 4222 by Uranus 1981 Apr 26

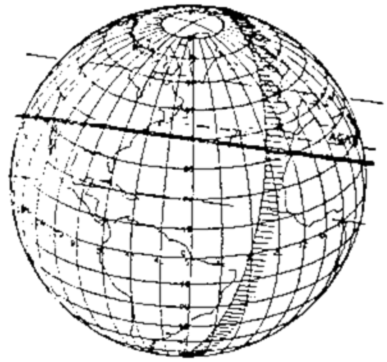


SAO 209308 by Egeria 1981 Apr 26

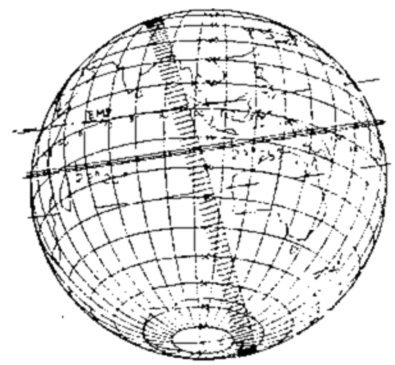






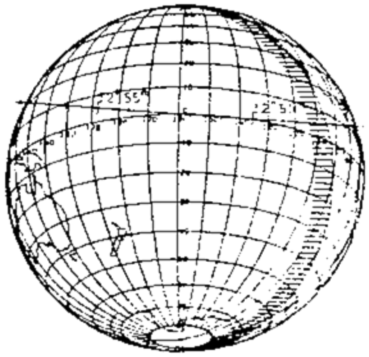


SAO 79051 by Vibilia 1981 Apr 29

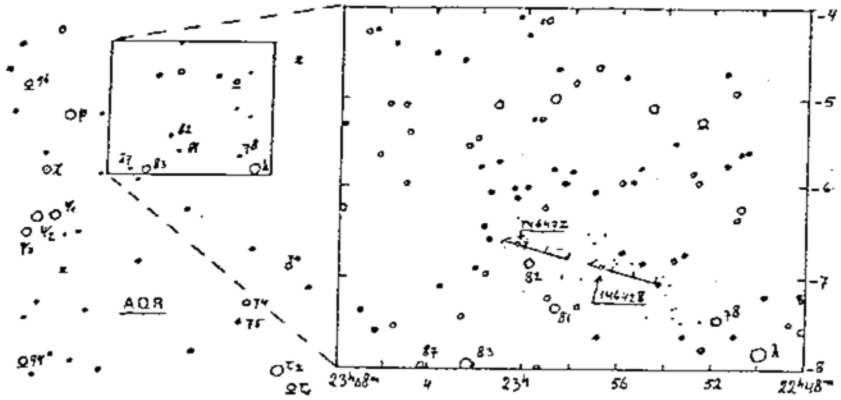


SAO 190234 by Minerva 1981 May 4

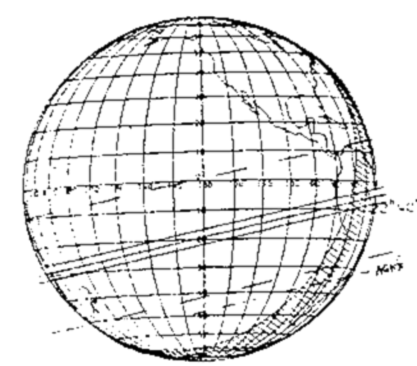
SAO 97880 by Melete 1981 May 9



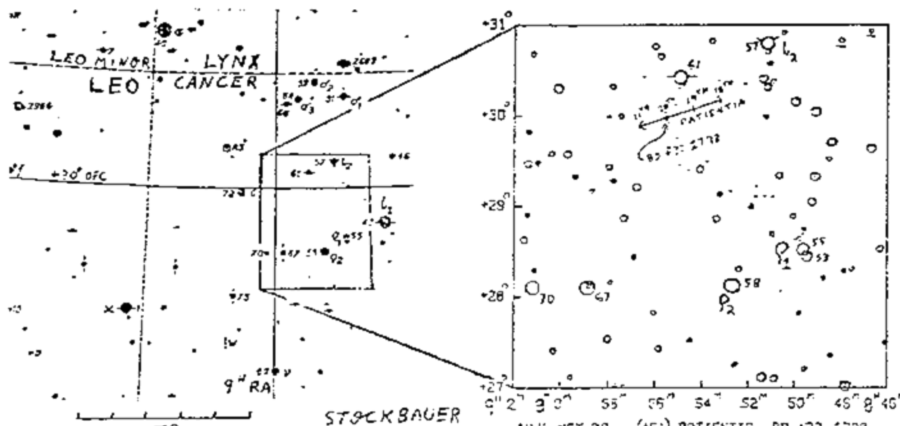
KMN 28 by Neptune 1981 May 10



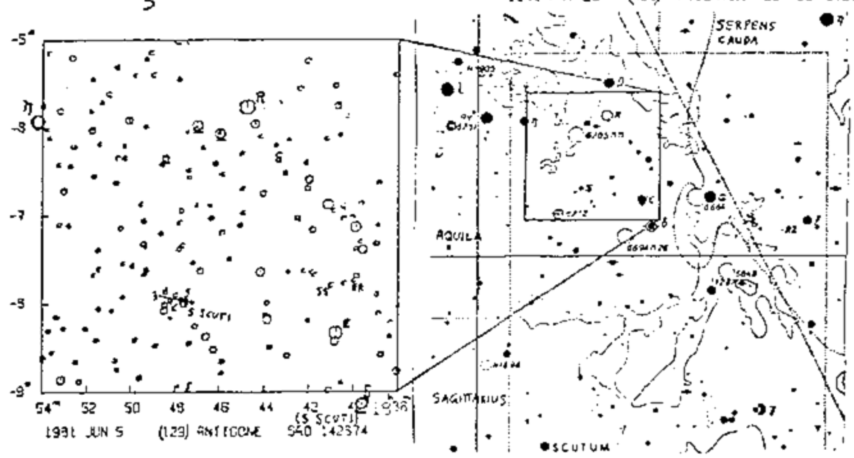
1981 MAI 17 28 BELLONA SAO 146428
1981 MAI 21 28 BELLONA SAO 146472

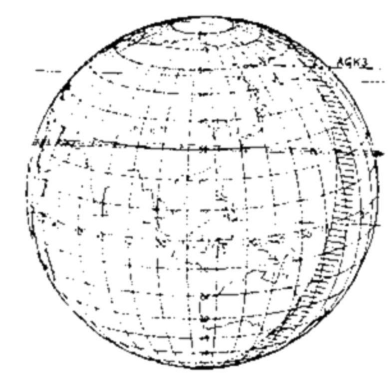


SAO 131847 by Pallas 1981 May 10



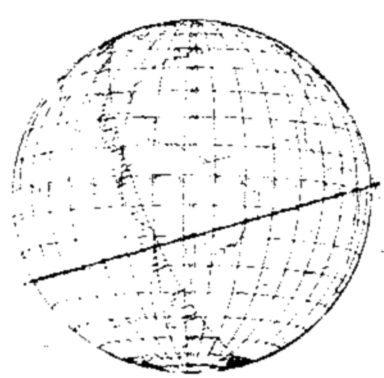
-00° 4138 by Daphne 1981 May 11



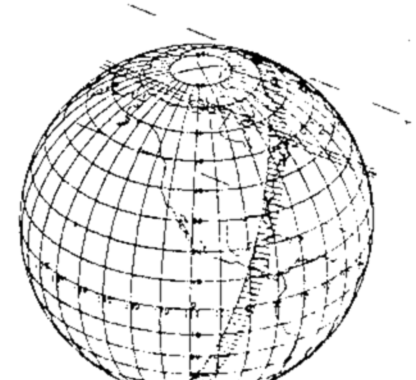


SAO 95447 by Arethusa 1981 May 13

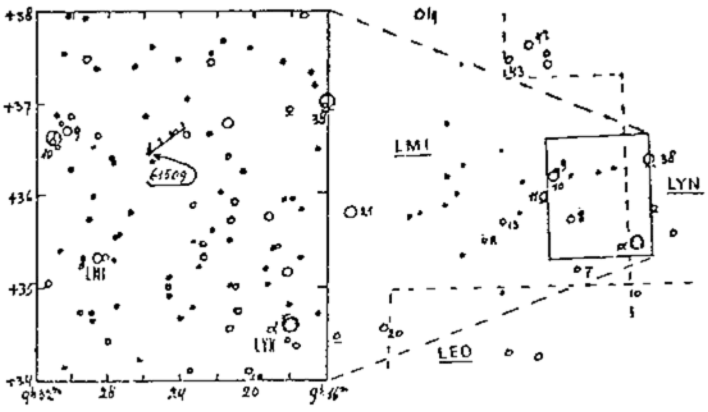
+22° 1766 by Alexandra 1981 May 14



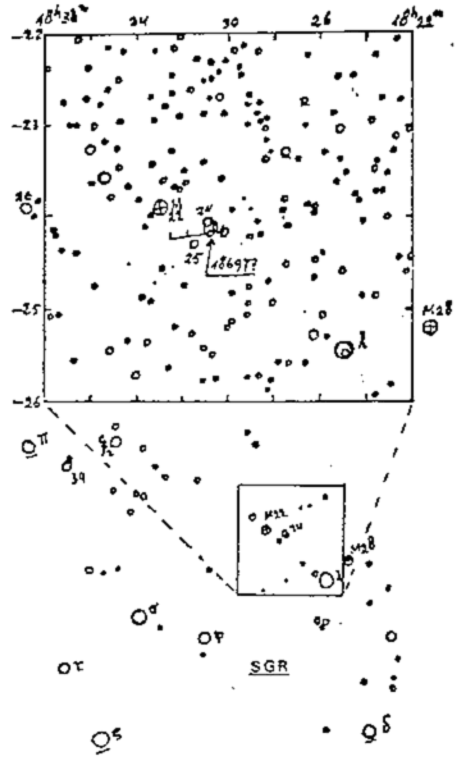
SAO 146428 by Bellona 1981 May 17



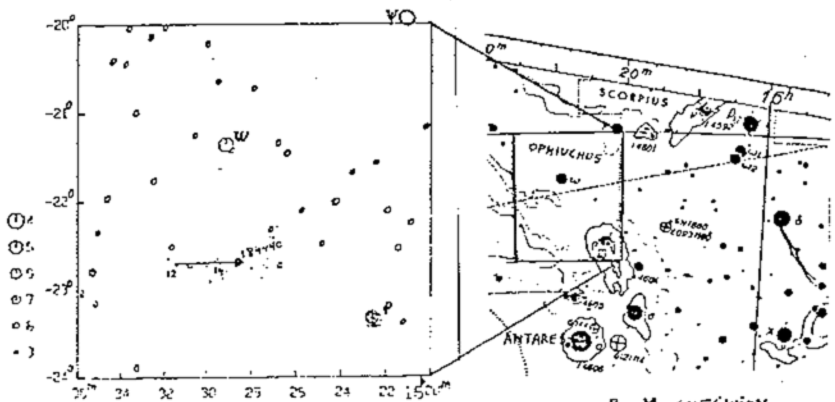
+30° 1798 by Patientia 1981 May 20



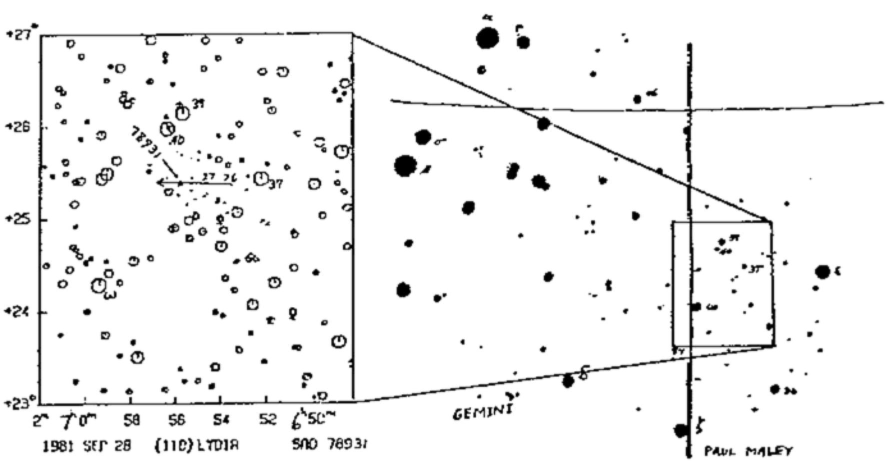
1981 JUN 5 617 PATROCLUS SAO 61509



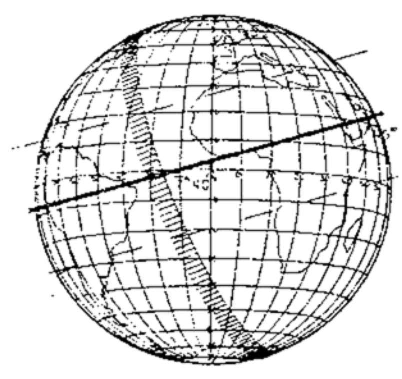
1981 JUN 13 88 THISBE SAO 186977



1981 JUN 14 (9) METIS SAO [illegible]

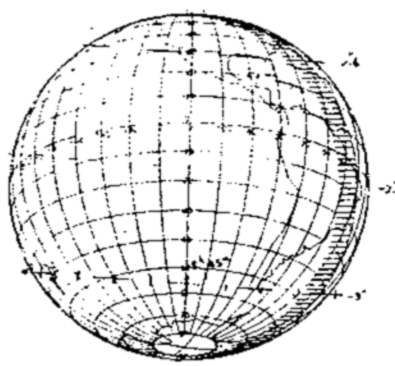


1981 SEP 28 (110) LYDIA SAO 78931

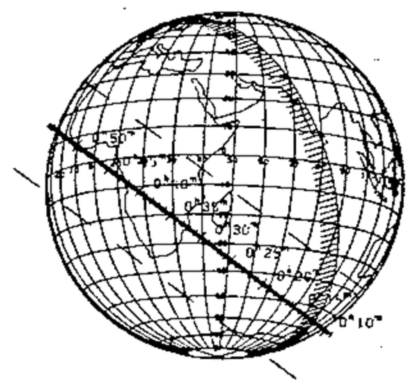


SAO 146472 by Bellona 1981 May 21

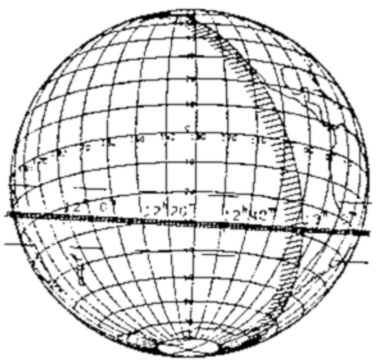
SAO 165440 by Irene 1981 May 22



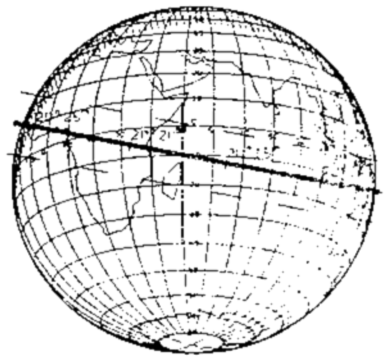
KMN 29 by Neptune 1981 May 24



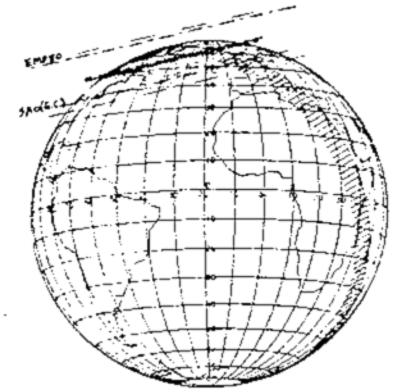
SAO 163084 by Hesperia 1981 May 26



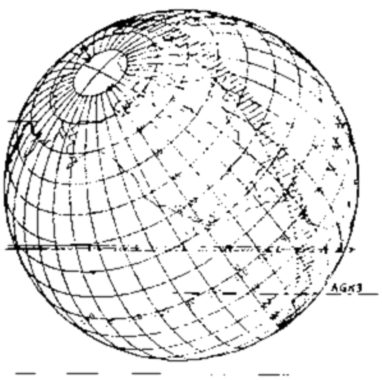
SAO 163352 by Parthenope 81 May 29



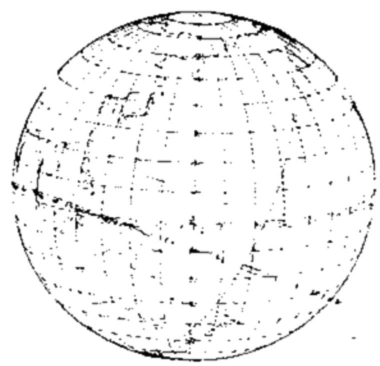
SAO 159945 by Hestia 1981 May 30



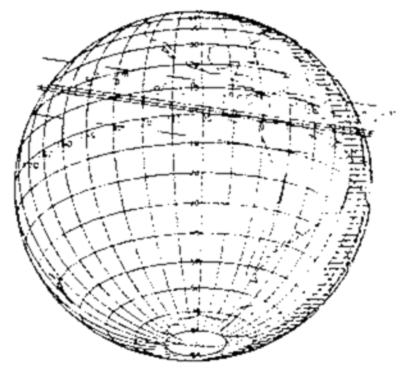
SAO 142674 by Antigone 1981 Jun 5



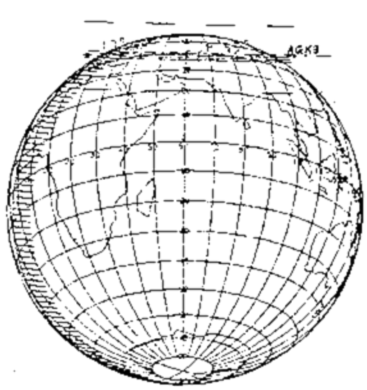
SAO 61509 by Patroclus 1981 Jun 5



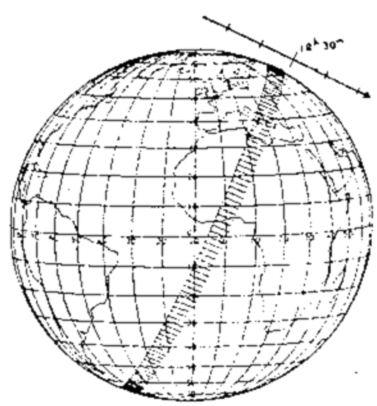
SAO 98622 by Ate 1981 Jun 7



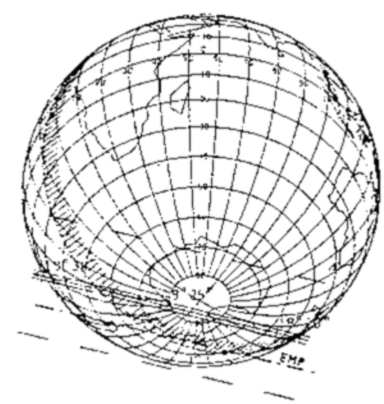
SAO 186977 by Thisbe 1981 Jun 13



SAO 184440 by Metis 1981 Jun 14

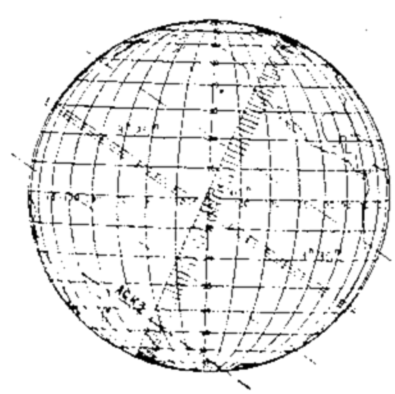


SAO 119207 by Nysa 1981 Jun 26

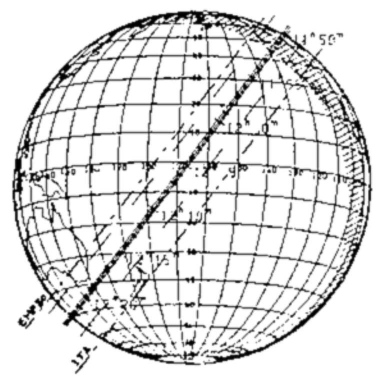


SAO 244226 by Euphrosyne '81 Jul 2

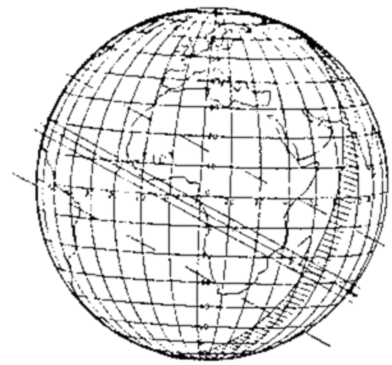
+23° 811 by Lydia 1981 Jul 11



SAO 120105 by Juno 1981 Jul 15

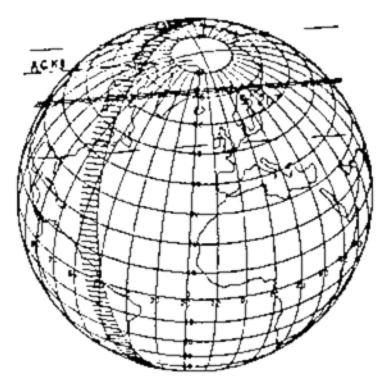


SAO 145972 by Melpomene 1981 Aug 7

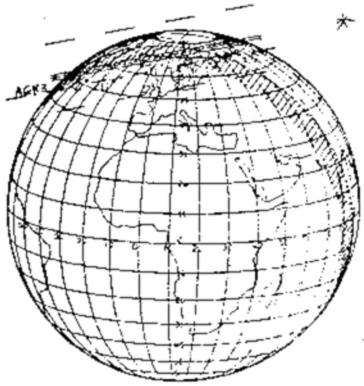


+04° 2598 by Vesta 1981 Aug 9

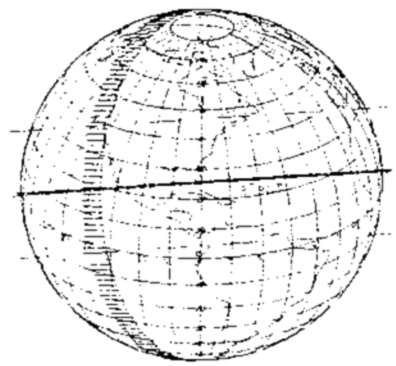
SAO 96278 by Eleonora 1981 Aug 9



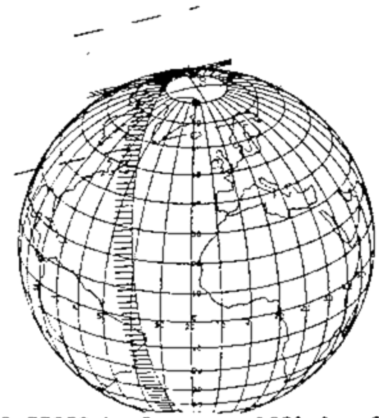
SAO 58135 by Julia 1981 Aug 12



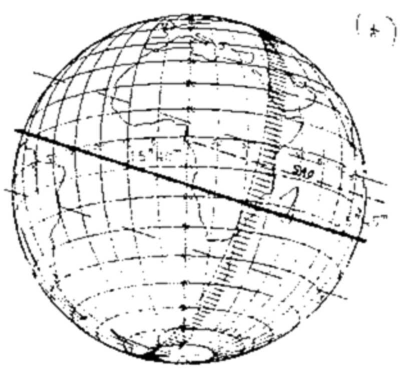
SAO 108373 by Aspasia 1981 Aug 20



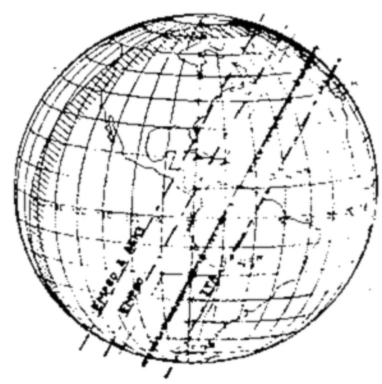
SAO 98007 by Lydia 1981 Aug 20



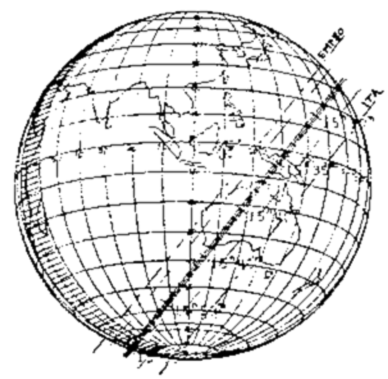
SAO 77350 by Panopaea 1981 Aug 26



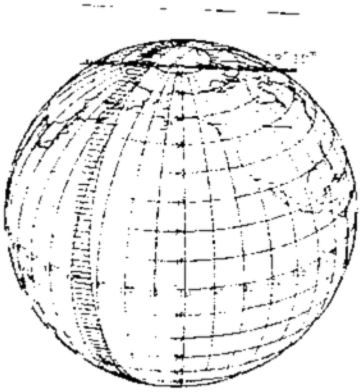
SAO 158784 by Aegina 1981 Aug 26



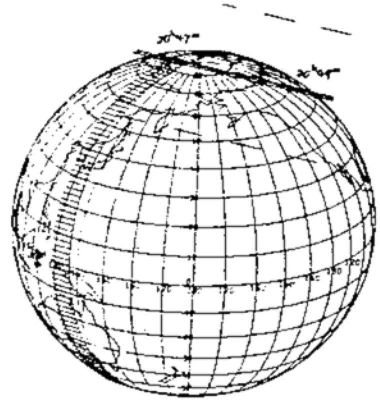
SAO 126198 by Artemis 1981 Aug 27



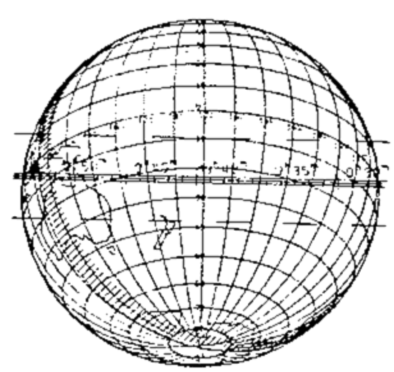
SAO 164747 by Melpomene 1981 Sep 4



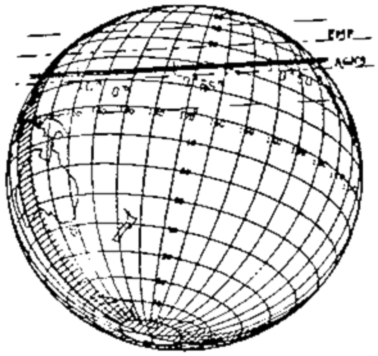
N26° 761 by Beatrix 1981 Sep 6



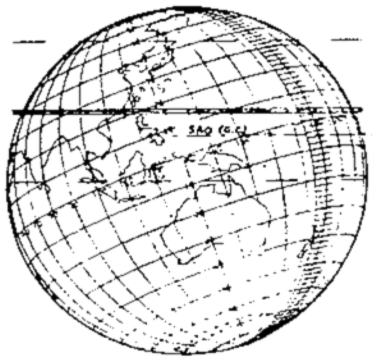
+21° 1864 by Klymene 1981 Sep 17



SAO 190936 by Diotima 1981 Sep 19

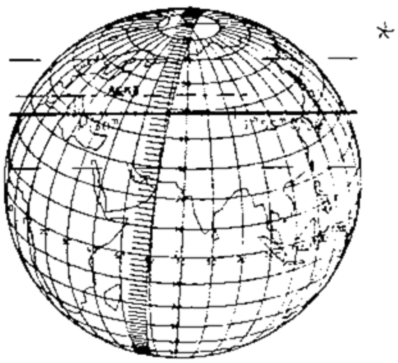


SAO 191415 by Irene 1981 Sep 20

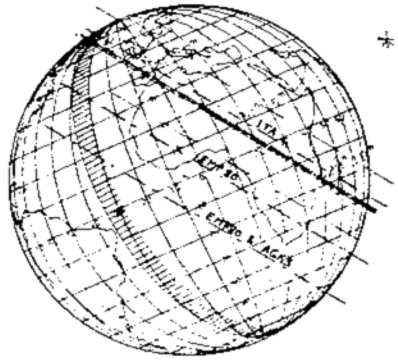


SAO 140280 by Laetitia 1981 Sep 23

SAO 118220 by Iris 1981 Sep 27



SAO 78931 by Lydia 1981 Sep 28



SAO 144809 by Artemis 1981 Oct 5

SAO 87010 by Pallas 1983 May 29

1983 5 29 (2) PALLAS SAO 87010
DIAMETER 538 KM = 0".28