THE MINOR PLANET BULLETIN

Bulletin of the Minor Planets Section
of the Association of Lunar and Planetary Observers

Vol. 3, No. 2, Part 1 A.D. 1975 October - December

23c

INTERPOLATING MINOR PLANET OR COMET POSITIONS BETWEEN EPHEMERIS DATES

by Prof. Frederick Pilcher
Illinois College
Jacksonville, Illinois 62650, USA

Ephemerides are normally printed at 0^h Ephemeris Time (ET), that is, for 8 pm Eastern Daylight Time, 7 pm Central Daylight Time, etc., of the preceding day. Ten day intervals are normally used except for rapidly moving objects for which the time interval may be shorter. To predict a position for a time other than 0^h ET on an ephemeris date, the time must first be expressed in days and decimal fractions thereof. With 1440 minutes in a day, every 0.01 day is 14.4 minutes, or for extreme accuracy every 0.00001 day is 0.864 seconds. In the following example days are expressed to hundredths, right ascension to $0^m.1$, declination to $1'$, but the method may be used to any desired level of accuracy.

This writer observed the minor planet 380 Fiducia at 12:05 am CDT Aug. 4, 1975. This converts to 5:05 ET, or 5 hrs 5 min = 305 minutes following the start of Ephemeris Day Aug. 4. This is 305/1440 of a day; expressed decimally it equals 0.21 days following Aug. 4.00; the time is thus 1975 Aug. 4.21.

A partial ephemeris of 380 Fiducia follows:

1975 Jul 27	$21^h\ 44^m.6$	7.4	$-20°\ 34'$	-69
Aug 6	21 37.2	8.4	-21 43	-65
Aug 16	21 28.8	8.2	-22 48	-52
Aug 26	21 20.6		-23 40	

Let α_0 be the right ascension on the ephemeris date preceding observation, α_1 be the right ascension on the following ephemeris date, α_2 be the right ascension on the ephemeris date subsequent to this, etc. This $\alpha_0 = 21^h44^m.6$, $\alpha_1 = 21^h37^m.2$, $\alpha_2 = 21^h28^m.8$, etc., in our example. The <u>first difference</u> $\Delta\alpha_0 = \alpha_1 - \alpha_0 = -7^m.4$. First differences are listed in the Leningrad ephemerides, except that the minus sign is omitted for right ascension because almost all asteroids have retrograde motion near opposition. Other first differences in this example are $\Delta\alpha_1 = \alpha_2 - \alpha_1 = -8^m.4$, $\Delta\alpha_2 = \alpha_3 - \alpha_2 = -8^m.2$.

The use of first differences is the process of linear interpolation. Commonly errors as high as $\pm 0^m.5$, $\pm 5'$ may arise, because first differences replace the actual curved paths by imaginary straight lines. These may be reduced by using second differences, and perhaps even third differences, in second-order and third-order interpolation schemes.
The <u>second difference</u> $\Delta_2\alpha_0 = \Delta\alpha_1 - \Delta\alpha_0 = -1^m.0$ in this example; $\Delta_2\alpha_1 = \Delta\alpha_2 - \Delta\alpha_1 = +0^m.2$. The <u>third difference</u> $\Delta_3\alpha_0 = \Delta_2\alpha_1 - \Delta_2\alpha_0 = +1^m.2$. One could continue in this manner if extreme accuracy in ephemerides is available; in most cases the use of second differences is sufficient for accuracy of order $\pm 0^m.1$, $\pm 1'$.

Let t denote the time between ephemeris date preceding observation and time of observation, in this example 8.21 days. Let T denote the time between successive ephemeris dates, here 10.00 days. Then the formula for third order interpolation in right ascension is:

$$\alpha = \alpha_0 + \frac{t}{T}\Delta\alpha_0 + \frac{1}{2!}\frac{t(t-T)}{T^2}\Delta_2\alpha_0 + \frac{1}{3!}\frac{t(t-T)(t-2T)}{T^3}\Delta_3\alpha_0 + \ldots$$

Substituting numbers to illustrate by example gives, for 1975 Aug. 4.21:

$$= 21^h44^m.6 + \frac{8.21}{10}(-7^m.4) + \frac{(8.21)(-1.79)}{2(100)}(-1^m.0) + \frac{(8.21)(-1.79)(-11.79)}{6(1000)}(+1^m.2) + \ldots$$

$$= 21^h44^m.6 - 6^m.07 + 0^m.07 + 0^m.03 + \ldots = 21^h38^m.6, \text{ rounding to the nearest } 0^m.1.$$

First, second, and third differences in declination are defined in analogous manner. In our example $\delta_0 = -20^\circ34'$; $\delta_1 = -21^\circ43'$; $\delta_2 = -22^\circ48'$; etc.; $\Delta\delta_0 = \delta_1 - \delta_0 = -69'$; $\Delta\delta_1 = \delta_2 - \delta_1 = 65'$; $\Delta\delta_2 = \delta_3 - \delta_2 = -52'$; $\Delta_2\delta_0 = \Delta\delta_1 - \Delta\delta_0 = +4'$; $\Delta_2\delta_1 = \Delta\delta_2 - \Delta\delta_1 = +13'$; $\Delta_3\delta_0 = \Delta_2\delta_1 - \Delta_2\delta_0 = +9'$. Then for 1975 Aug. 4.21:

$$\delta = \delta_0 + \frac{t}{T}\Delta\delta_0 + \frac{1}{2!}\frac{t(t-T)}{T^2}\Delta_2\delta_0 + \frac{1}{3!}\frac{t(t-T)(t-2T)}{T^3}\Delta_3\delta_0 + \ldots$$

$$= -20^\circ34' + \frac{8.21}{10}(-69') + \frac{(8.21)(-1.79)}{2(100)}(+4') + \frac{(8.21)(-1.79)(-11.79)}{6(1000)}(+13') + \ldots$$

$$= -20^\circ34' - 56'.6 - 0'.3 + 0'.4 + \ldots = -21^\circ30', \text{ rounding to the nearest } 1'.$$

However in this case the position measured with the Vehrenberg Atlas Stellarum grid was $21^h36^m.9$, $-21^\circ37'$. The residual, which is the observed position minus the computed position (O-C), is

$$21^h36^m.9 - 21^h38^m.6,\ -21^\circ37' - (-21^\circ30') = -1^m.7,\ -7'.$$

It is this writer's experience that for well over 90% of all the asteroids brighter than magnitude 14 which he has observed with the aid of the Leningrad Ephemerides of Minor Planets and measured off Vehrenberg star atlas grids, the residuals are smaller than $\pm\ 0^m.4$, $\pm\ 4'$. Larger residuals occasionally, but not always, appear for orbits published in 1965 or earlier. As these older orbits are being improved, the incidence of appreciable residuals should decrease greatly in the next five to ten years.

Editor's Comment: The Editor wishes to thank Prof. Pilcher for his fine paper, which was written in response to several letters received which asked about interpolation procedures. It is hoped that many readers will be helped by this discussion.

MINOR PLANET VISUAL PHOTOMETRY LIST: OCTOBER-DECEMBER 1975

by Derek Wallentine and Alain Porter

Four close passages are featured among the visual photometry opportunities for the last three months of 1975. For all but one of the listed planets there is no knowledge of their lightcurves, so observers of these events could make significant contributions to our knowledge of these bodies.

One of the closest appulses is that of 444 Gyptis to the object variously known as NGC 2261, Hubble's "Variable Nebula", and R Monocerotis. For about two days centered on minimum separation, it will be excellently placed in a field of suitable comparison stars of similar magnitude. Also favorable (though faint) is 113 Amalthea's passage through the field of Z Ceti. The very close passage of 1061 Paeonia is included for those fortunate observers among us equipped with telescopes of 30 cm aperture or greater. Although the T Tauri sequence extends only through 13.9 magnitude, observations of light variations would still be useful, even if precise values could not be determined due to lack of comparison stars. Incidentally, at opposition this planet will be about two degrees from the ecliptic and consequently may be a tenth of a magnitude or so brighter because of the opposition effect (cf. table, MPB 2, 6 (1974)).

Below are given the asteroid's number, name, opposition date and opposition magnitude; the number, name and type of AAVSO chart; and the date, separations and position angles (relative to the chart variable star) of the crossing. The following abbreviations apply:

LU - light curve unknown; observations urgently requested

PL - planet on Pilcher list (MPB 2, 13-14 (1974)): opposition highly favorable this year

e - extrapolated position, that is, an extension of the asteroid's apparent track beyond the last published ephemeris position.

c - closest approach

* - AAVSO "b" type star chart useful only for the location of the field

mv - visual magnitude (assumed to be 0.8 mag. brighter than photographic magnitude)

Asteroid	Opposition Date	Mag.	Chart(s)	Date (0h UT)	Sep	PA
246 Asporina	Sept 24	$12.5m_v$	2352-09 V Cet	Oct 1	41'	16°
	LU		"b"*, "d"	3	23	337
				4	22 c	301
				5	30	276
				7	52	256
113 Amalthea	Oct 16	$11.9m_v$	0101-02 Z Cet	Oct 31	36'	60°
	LU		"b"*, "d"	Nov 2	17	30
				3	9 c	333
				4	18	284
				6	41	268
200 Dynamene	Dec 9	$11.4m_v$	0520+34 S Aur	Nov 7	28'	157°
	LU		"b", "d"	9	23	184
				10	22 c	201
				11	24	218
				13	32	241

Asteroid	Opposition Date	Mag.	Chart(s)	Date (0^h U.T.)	Sep	PA
530 Turandot	Oct 6	$12.3m_v$	0019-09 S Cet	Nov 12	33'	105°
	LU, PL		"b"*, "d"	14	28	100
				16 e	24	94
				18 e	21 c	83
				20 e	22	71
1061 Paeonia	Nov 28	$14.1m_v$	0416+19 T Tau	Nov 20	19'	83°
	LU, PL		"b"*, "d"	21	7	83
				$\sim 13^h$	<1 c	0
				22	5	271
				23	17	269
444 Gyptis	Dec 26	$12.2m_v$	0633+08 R Mon	Nov 29	16'	76°
	LU		"b25"*, "d"	30	7	86
				$\sim 16^h$	2 c	180
				Dec 1	4	243
				2	14	247
16 Psyche	Dec 7	$9.4m_v$	0446+17 V Tau	Dec 5	29'	44°
			"b"	7	19 c	345
				9	40	293
236 Honoria	Dec 4	$11.8m_v$	0422+09 R Tau	Dec. 17	21'	63°
	LU		"b17"*, "d11",	18	11	44
			"e3"	19	7 c	333
				20	14	297

Note: Planets are listed in order of central crossing date, c.

As indicated previously (MPB 2, 31-32, 3, 20 (1975)) estimates should be made every few minutes for a number of hours -- preferably for 6 to 10 hours if possible to enable a full rotation or more to be observed. Observations covering several nights are highly desirable in order to define the rotation period more precisely.

Proper observing charts may be obtained for $ 0.25 (US) each from the American Association of Variable Star Observers ("AAVSO"), 187 Concord Avenue, Cambridge, Massachusetts 02138, U.S.A. by identifying them by their number, variable star name and small letter subscript. If possible, obtain the chart(s) well ahead of time so that you can study the field before the passage of the planet, especially in the case of the fainter planets.

Photometry Report Forms are available free from co-author Alain Porter, 10 Sea Lea Drive, Narragansett, Rhode Island 02882, U.S.A. Their use is recommended for all visual photometric observations, and they may be best for photoelectric and photographic photometry as well. Please enclose a large, self-addressed stamped envelope to defray Alain's costs. Reports of any observations should be sent to Mr. Porter at the above address; the Section Recorder would also appreciate a copy for section files.

SECTION NEWS

PUBLISHING PLANS. Subscribers should note that vol. 3, no. 2 is being published in two parts, this being the first part. A larger second part will follow in a few weeks, and will include articles by M.A. Combes, A.T. Son, June LoGuirato, and others which should be of considerable interest.

PALLAS/VESTA CHART. Dr. J.U. Gunter has very kindly supplied us with free tracking charts for the 2 Pallas/4 Vesta appulse in November, a copy of which is enclosed. Try to observe these planets as they draw together if possible. Cf. MPB 3, 10 (1975) for further information.

233 ASTEROPE. Recent letters from Prof. Frederick Pilcher, Alain Porter, and Derek Wallentine indicate that 233 Asterope shows distinct light variations of about 0.2 magnitude based on visual photometry in early September, 1975. Prof. Pilcher is presently making a full least squares reduction of the data, and intends to report the findings in a paper in MPB.

At this time, however, more observations of 233 Asterope are very much needed to confirm the rotation period and improve its precision. While photoelectric measures would be highly desirable, a series of visual observations of several hours length would be highly valuable. Differential measurements alone will suffice according to Prof. Pilcher.

Prof. Pilcher has extrapolated the ephemeris of Asterope beyond that given in the Leningrad Ephemerides of Minor Planets; the error may well be as great as ± 5' by mid-October, but it should enable observers to find the planet. It is as follows:

	α_{1950}	δ_{1950}
1975 Sept. 15 (0^h U.T.)	$21^h05^m.8$	$-4^\circ31'$
Sept. 25	21 03.8	- 5 28
Oct. 5	21 04.3	- 6 13
Oct. 15	21 07.1	- 6 41

MPB IN THE FUTURE. As indicated on the previous page the Editor has received many fine papers for publication. In keeping with the general policy of the Minor Planet Bulletin we intend to publish these papers as soon as possible (usually in less than 90 days of receipt), and without making any page charges of the authors. We believe that that the increased number of papers submitted is a sign of deepening interest in minor planet astronomy by the professional and advanced amateur astronomer, and we welcome it.

At the same time more papers means longer issues, or, as in this case, publishing an issue in parts. It means higher postal expenses (quite apart from the fact that U.S. domestic postal rates for first class mail may increase 30% in the near future). If some articles contain graphs and complicated tables we run those pages offset although it costs more; where possible we resort to low-cost mimeographing since we want to keep our subscription rates as low as possible.

The Editor feels that he should mention these facts of journalistic life in order that our readers might make some suggestions concerning the future of MPB. Financially we are in fairly good shape, and there is no present need for a subscription increase at this time -- even if the U.S. postal rates increase in a few months. But a problem could develop about a year from now, especially if we are running about 18 to 22 pages an issue.

Several possibilities for future development come to mind: (1) increase the number of paid subscriptions. This is easier said than done. The present number is 84 paid subscriptions. A number of free samples of vol. 3 no. 1 were mailed in July to leading observers around the world, and some have responded by subscribing. Others have written highly enthusiastic letters about the last issue, but entered no subscription. Perhaps a better way to go in the campaign to increase the paid subscriptions is to have the rank and file of our members encourage some of their astronomically-oriented friends to subscribe. If we could secure a total of about 250 paid subscriptions (a wild dream??) we could readily afford longer issues without a subscription increase (in spite of postal rate increased), and we might be able to run the entire issue on an offset press, which would improve its appearance. (2) mail within the U.S. on a non-first class basis. This has been explored with the Post Office, but it does not seem worthwhile given the small circulation of MPB, especially since we want our issues to be delivered fairly promptly in order that important astronomical events not be missed.

Other possibilities for future growth and development of MPB might include acceptance of selected advertising, or publishing some of the longer papers in an annual or semi-annual supplement series which would be separately subscribed for. Let's hear your ideas concerning these "growing pains" MPB is having while

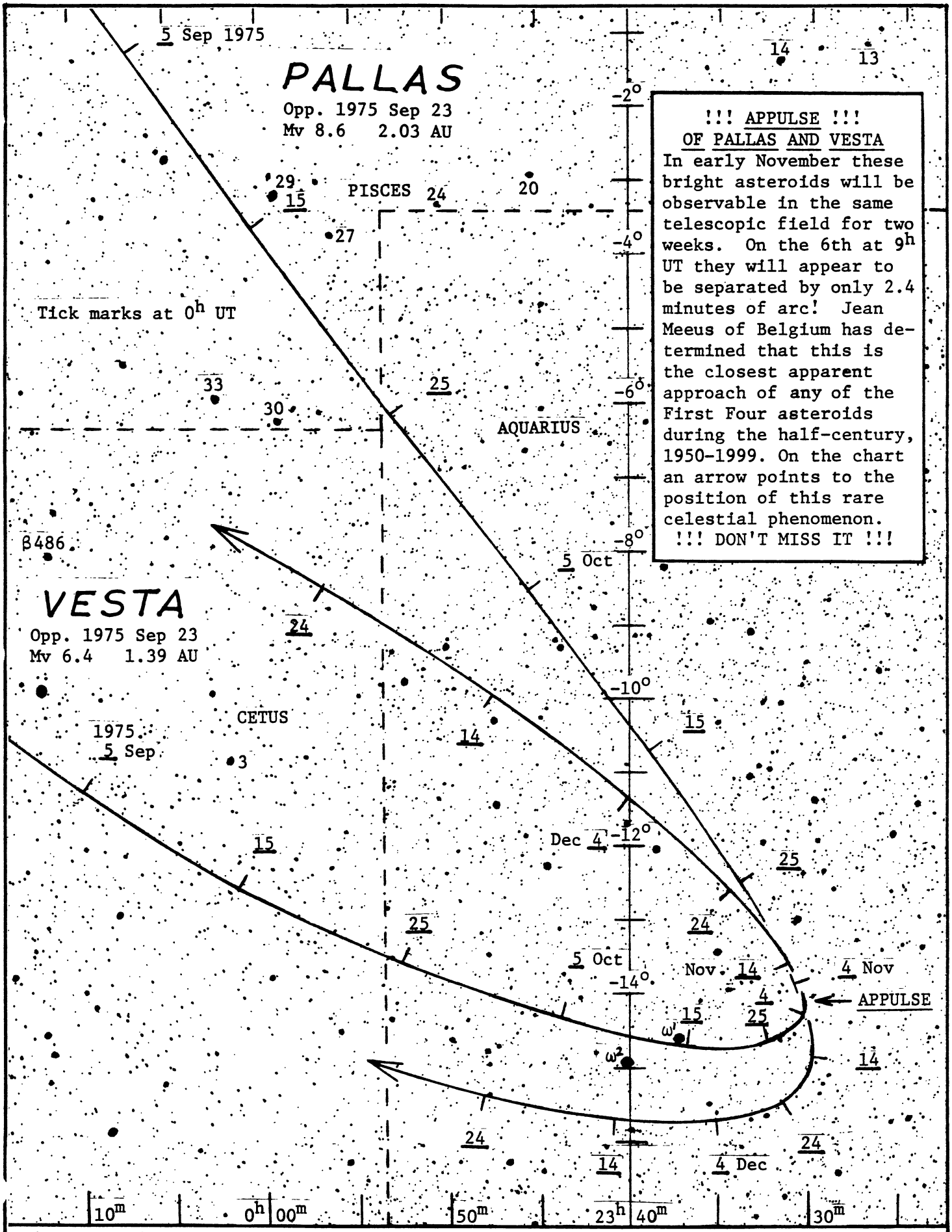
there is plenty of time to consider alternatives. What we wish is an improved journal which will be of interest to professional and non-professional astronomers alike.

ANNUAL VOLUME OF MINOR PLANET EPHEMERIDES

Dr. Paul Herget, Director of the Cincinnati Observatory, reports that The Institute of Theoretical Astronomy, Leningrad, U.S.S.R., has generously agreed to provide a limited number of extra copies of their Ephemerides of Minor Planets for distribution other than to established astronomical libraries and observatories in the western world. The price for these volumes will be $ 5.00 each, including packaging and postage within the U.S.A. This income will augment the subvention which the Minor Planet Center at the Cincinnati Observatory receives from the International Astronomical Union. All checks or money orders should be made payable to "Cincinnati Observatory." The address is

Cincinnati Observatory
Observatory Place
Cincinnati, Ohio, 45208

U.S. subscribers will rejoice in this news, and should act without delay to secure a copy of the volume for the year 1976. A serious minor planet observing program is almost impossible without it.



!!! APPULSE !!!
OF PALLAS AND VESTA

In early November these bright asteroids will be observable in the same telescopic field for two weeks. On the 6th at 9h UT they will appear to be separated by only 2.4 minutes of arc! Jean Meeus of Belgium has determined that this is the closest apparent approach of any of the First Four asteroids during the half-century, 1950-1999. On the chart an arrow points to the position of this rare celestial phenomenon.

!!! DON'T MISS IT !!!

2 PALLAS. 4 VESTA. Tracking Chart No. 251 by J. U. Gunter. Star Field by permission from Hans Vehrenberg's Photographic STAR ATLAS, Plates 196, 231, 232, 267, and 303.

THE MINOR PLANET BULLETIN

Bulletin of the Minor Planets Section
of the Association of Lunar and Planetary Observers

Vol. 3, No. 2, Part 2 A.D. 1975 October - December

MINOR PLANETS AT UNUSUALLY FAVORABLE OPPOSITION IN 1976

by Prof. Frederick Pilcher
Illinois College
Jacksonville, Illinois 62650, USA

Abstract: A list is presented of 91 minor planets which are much brighter than usual at their 1976 oppositions. Observations are especially urged for 1580 Betulia and 944 Hidalgo at their coming close approaches to Earth, and ephemerides are provided.

The following minor planets will be much brighter than usual at their 1976 oppositions. Observers are encouraged to note any that lie near the limit of their equipment and give these special consideration in their programs. Many years may pass before the next opportunity for observation.

This list has been compiled on the basis of a comparison of the magnitudes given in the 1976 Ephemerides of Minor Planets at opposition with the magnitude range in Tables of Minor Planets.[1] Any planets whose perihelion and aphelion opposition magnitudes differ by 2.0 or more and in 1976 will be within $0^m.3$ of the brightest possible have been included. For planets brighter than magnitude 13 which are within the range of many of our observers these standards have been somewhat relaxed so that more planets will be included.

No.	Name	Opposition Date	Mag.	No.	Name	Opposition Date	Mag.
6	Hebe	Sep 27	8.1	129	Antigone	Jun 7	10.1
14	Irene	Jun 7	10.0	155	Scylla	Dec 20	13.6
15	Eunomia	Aug 9	9.0	161	Athor	Oct 2	12.3
25	Phocaea	Jul 3	10.2	163	Erigone	Oct 22	12.4
41	Daphne	May 30	10.1	181	Eucharis	Dec 10	12.0
65	Cybele	May 28	11.9	198	Ampella	Oct 8	11.0
70	Panopaea	Oct 5	11.7	225	Henrietta	Jul 15	12.4
78	Diana	Dec 1	11.4	227	Philosophia	May 7	13.0
80	Sappho	Oct 16	10.3	240	Vanadis	Dec 23	11.9
82	Alkmene	Apr 5	11.9	245	Vera	Nov 12	12.5
89	Julia	Jul 25	10.4	258	Tyche	Oct 11	11.4
93	Minerva	Jun 1	11.4	262	Valda	Dec 12	14.5
101	Helena	Sep 20	11.6	284	Amalia	May 19	13.0
106	Dione	Dec 18	12.2	285	Regina	Aug 22	14.7
112	Iphigenia	Aug 5	12.7	313	Chaldaea	Dec 21	11.4

No.	Name	Opposition Date	Mag.	No.	Name	Opposition Date	Mag.
352	Gisela	Sep 29	12.7	1050	Meta	Sep 14	16.4
385	Ilmatar	Apr 17	11.9	1088	Mitaka	Nov 11	13.7
394	Arduina	Jul 19	13.1	1153	Wallenbergia	Aug 29	14.5
432	Pythia	Jun 22	11.5	1187	Afra	Oct 21	14.7
477	Italia	Aug 15	12.9	1216	Askania	Jul 5	14.3
517	Edith	Nov 19	13.4	1227	Geranium	Jul 3	14.7
561	Ingwelde	Nov 7	15.3	1253	Frisia	Sep 7	16.6
599	Luisa	Sep 15	11.6	1293	Sonja	Jul 1	15.9
647	Adelgunde	Nov 15	14.2	1318	Nerina	Mar 23	14.2
685	Hermia	Sep 29	14.2	1324	Knysna	Jun 19	14.6
686	Gersuind	Oct 30	13.6	1392	Pierre	Oct 18	14.8
689	Zita	Oct 8	14.1	1435	Garlena	Feb 5	16.6
690	Wratislavia	Sep 21	12.0	1452	1938 DZ1	Jan 2	16.2
712	Boliviana	Nov 14	11.4	1459	Magnya	Sep 28	14.7
751	Faïna	Dec 24	12.6	1477	Bonsdorffia	Nov 29	14.7
785	Zwetana	Apr 1	12.3	1479	Inkeri	Nov 24	14.8
810	Atossa	Aug 1	15.2	1493	Sigrid	Oct 7	14.3
849	Ara	Sep 7	12.6	1498	1938 SK1	Aug 3	16.1
881	Athene	Jul 7	15.5	1506	Xosa	May 13	14.9
888	Parysatis	Jan 10	13.4	1580	Betulia	May 22	11.5
922	Schlutia	Jul 14	15.4	1609	1951 NL	Aug 6	13.5
944	Hidalgo	Oct 18	14.7	1615	Bardwell	Dec 15	14.6
958	Asplinda	Oct 29	15.7	1622	1952 EA	Aug 10	14.9
982	Franklina	Jun 7	14.1	1631	1926 TH	Sep 21	14.4
1011	Laodamia	Mar 1	13.8	1638	1912 QX	May 21	15.4
1014	Semphyra	Mar 10	15.6	1681	1948 WE	Feb 16	14.3
1024	Hale	Aug 14	14.7	1689	Floris-Jan	Sep 11	13.1
1034	Mozartia	Sep 5	14.2	1703	1930 RB	Jul 30	15.4
1036	Ganymed	May 23	13.1	1710	1941 UF	Jul 24	15.3
1048	Feodosia	Apr 16	13.1	1747	1947 NH	Jun 19	14.0
				1792	Reni	Dec 18	14.5

Note: The magnitudes given above are photographic. Visual magnitudes depend upon the color of the minor planet; in most cases minor planets are about 0.8 magnitude brighter visually than these photographic values.

Two minor planets with exceptional orbits, 1580 Betulia and 944 Hidalgo, are 5 to 8 magnitudes brighter at their 1976 oppositions than at any other time between 1963 and 1989. All observers are especially urged to take advantage of these rare opportunities to make extensive studies of these remarkable objects.

Betulia is an Amor-type planet with a perihelion distance of 1.119 AU, the largest inclination of any numbered minor planet, 52°, and a period of revolution of 3.2535 years. Betulia thus makes almost exactly 4 revolutions around the Sun in 13 years, and close approaches to Earth recur at this time interval. Betulia will in fact be closer to the Earth in May 1976 than at any other time in the current century. It will be near visual magnitude 11 for several days and be easily visible in small telescopes, moving southward at an exceptionally rapid 15 minutes of arc every hour! Even a few minutes should be sufficient time to discern the motion. An ephemeris at 6 hour intervals near the time of closest approach is included. The listed magnitudes are photographic; visually Betulia should be about $0^m.8$ brighter.

The orbit of 944 Hidalgo, with a = 5.82, q = 1.999, Q = 9.64, i = 42°.5, more nearly resembles the orbits of short period comets than that of any other asteroid. Hidalgo is the only asteroid which can approach Jupiter more closely than 1.1 AU, which seems to be the minimum distance to avoid large perturbations. Most short period comets make repeated approaches to Jupiter closer than 1.1 AU. Unlike comets, however, Hidalgo has never showed a trace of fuzziness or coma; it has always been entirely starlike in appearance. Furthermore no evidence of non-gravitational forces due to recoil from expelled gases is observed in its motion. However there are two objects classified as short period comets, P/Neujmin I and P/Arend-Rigaux, which have been starlike in appearance except for a faint coma at the discovery apparition only, on which no observable nongravitational forces act, and which approach Jupiter only at intervals of many centuries.

It therefore seems likely that Hidalgo, like P/Neujmin I and P/Arend-Rigaux, is a very old comet from which nearly all volatiles have been evaporated, and little besides a nonvolatile nucleus remains. The close approach in the latter part of 1976 provides an opportunity to determine whether Hidalgo is a comet or an asteroid. Besides photoelectric, spectrophotometric, and infrared radiometric observations, professional astronomers with access to large telescopes are urged to obtain image tube spectrograms of Hidalgo and search these for traces of the cometary emission bands. While a positive observation of cometary bands will determine the nature of Hidalgo conclusively, a negative observation will be indecisive. In the latter case Hidalgo might still be a dead comet which no longer evolves enough gas to be observable. Control observations should be made on comets P/Neujmin I and P/Arend-Rigaux at their next returns.

Late 1976 offers history buffs an opportunity to observe recently-recovered 155 Scylla. Discovered in 1875 under conditions similar to those in 1976 by Johann Palisa, it was lost within two weeks and remained lost for 95 years. In 1970 Conrad Bardwell of Cincinnati Observatory succeeded in identifying several unnumbered planets observed in the intervening years with Scylla and published a reliable orbit. Paul Wild of Berne, Switzerland, recovered Scylla the following year very close to Bardwell's ephemeris. Although the published magnitude of 13.6 photographic (about 12.8 visual) may seem discouraging for owners of small telescopes, Palisa discovered Scylla with a 6-inch (15 cm) instrument. Scylla may therefore be somewhat brighter than predicted. The writer will appreciate communications from any observers who can report either positive or negative observations. An ephemeris of Scylla will be published in a subsequent issue of the Minor Planet Bulletin.

Reference

1. Pilcher, F., and Meeus, J., Tables of Minor Planets, 1973. Published privately by the authors.

Appendix

1976 CLOSE APPROACH EPHEMERIS OF 1580 BETULIA

		R.A. (1950)	Dec.	Delta	m
1976 May 17	0^h ET	$16^h\ 58^m.6$	+22° 06'	0.161 AU	12.9 photographic
	6	16 55.9	+21 08		
	12	16 53.2	+20 07		
	18	16 50.4	+19 03		
18	0	16 47.6	+17 58	0.152	12.7
	6	16 44.7	+16 50		
	12	16 41.8	+15 41		
	18	16 38.8	+14 30		

(continued on the next page)

(1580 Betulia Ephemeris continued)

1976 May 19	0hET	16h 35m.8	+13°17'	0.144	12.4
	6	16 32.8	+12 01		
	12	16 29.7	+10 43		
	18	16 26.6	+ 9 23		
20	0	16 23.4	+ 8 02	0.138	12.2
	6	16 20.2	+ 6 39		
	12	16 16.9	+ 5 14		
	18	16 13.6	+ 3 48		
21	0	16 10.2	+ 2 20	0.133	12.0
	6	16 06.8	+ 0 51		
	12	16 03.3	- 0 40		
	18	15 59.8	- 2 11		
22	0	15 56.3	- 3 44	0.131	11.9
	6	15 52.8	- 5 17		
	12	15 49.2	- 6 51		
	18	15 45.6	- 8 24		
23	0	15 41.9	- 9 57	0.130	11.7
	6	15 38.2	-11 30		
	12	15 34.5	-13 02		
	18	15 30.8	-14 34		
24	0	15 27.0	-16 06	0.131	11.7
	6	15 23.2	-17 36		
	12	15 19.4	-19 04		
	18	15 15.6	-20 31		
25	0	15 11.8	-21 57	0.135	11.9
	6	15 08.0	-23 21		
	12	15 04.1	-24 42		
	18	15 00.3	-26 03		
26	0	14 56.4	-27 22	0.140	12.1

1976 OPPOSITION EPHEMERIS OF 944 HIDALGO

	R.A. (1950)	Dec.	r	Delta	m	
1976 Sep 29	2h 02.4	+14°46'	2.430	1.500	15.1	photographic
Oct 4	1 55.8	+16 05				
Oct 9	1 48.4	+17 25	2.380	1.406	14.8	
Oct 14	1 40.2	+18 44				
Oct 19	1 31.2	+20 03	2.332	1.345	14.6	
Oct 24	1 21.6	+21 20				
Oct 29	1 12.2	+22 33	2.286	1.318	14.6	
Nov 3	1 02.8	+23 43				
Nov 8	0 53.7	+24 46	2.244	1.324	14.7	
Nov 13	0 45.2	+25 45				
Nov 18	0 37.5	+26 41	2.204	1.358	14.8	
Nov 23	0 31.1	+27 33				
Nov 28	0 25.2	+28 23	2.167	1.415	15.0	
Dec 3	0 20.8	+29 11				
Dec 18	0 17.5	+29 58	2.133	1.489	15.1	

Editor's Comment: Many thanks are due Prof. Pilcher for His fine article, now something of an annual tradition in MPB. Section members should give particular consideration to these favorably placed planets as instrumentation permits. A special effort should be made in the cases of 1580 Betulia and 944 Hidalgo.

PLANETS 1580 BETULIA AND 1620 GEOGRAPHOS IN 1976

by Jean Meeus
Heuvestraat 31
3071 ERPS-KWERPS, Belgium

Almost every year the "recreational celestial mechanics" brings us something new. In 1975 we had the closest approach of Eros of the present century, and later the close Pallas-Vesta conjunction. In 1976, it's the interesting motions of 1580 Betulia and 1620 Geographos which have our attention.

Betulia, discovered in 1950, has the highest orbital inclination (52°) of all numbered minor planets. With a perihelion distance of 1.12 AU, Betulia is a member of the Amor group; its orbital eccentricity is high (0.49).

The perihelic oppositions of Betulia repeat at intervals of 13 years (4 times the revolution period of 3.25 years), and it was at such a perihelic opposition that the minor planet was discovered in 1950. The next perihelic opposition took place in 1963, and the next one will occur in 1976.

At a perihelic opposition, Betulia is near the descending node of its orbit, and thus moving rapidly southwards.

Betulia will reach the perihelion of its orbit on 1976 May 3, at 1.119 AU from the Sun, and its descending node on May 24. The opposition in celestial longitude will occur on May 21, and that in right ascension the next day. The least distance to the Earth will occur on May 22; the planetoid will then move six degrees southward with respect to the stars, and will be of photographic magnitude 11.7.

At the beginning of August 1976 Betulia will be a faint object of magnitude 18, at declination -68° in the constellation of Musca.

It is remarkable that in 1976 Betulia will be closer to the Earth than ever since the time of its discovery in 1950. Here are the least distances to the Earth at the three mentioned perihelic oppositions:

1950 May 18 ..... 0.188 AU
1963 May 20 ..... 0.156 AU
1976 May 22 ..... 0.130 AU

Geographos, discovered in 1951, is a member of the Apollo group of minor planets: its perihelion lies inside the Earth's orbit, at 0.827 AU from the Sun.

In 1976 Geographos will not be brighter than magnitude 15, but the interesting point is that the planetoid will be twice in opposition, and between these oppositions the object will be in inferior conjunction with the Sun.

The first opposition will take place on 1976 January 25, this being the date of the opposition in celestial longitude. At that instant Geographos will be 1.41 AU distant from the Sun.

Geographos will cross the Earth's orbit ($r = 1$) on April 14 and accelerate further as it will fly to his perihelion. The minor planet will reach perihelion on June 7; on that date, its heliocentric longitude will increase each day by 1.56 degree (Earth: 0.96 degree). Moving faster than the Earth, Geographos will be in inferior conjunction on 1976 June 12. However, as seen from the Earth, the minor planet will be 42° south of the Sun. Still going faster than Earth, but now receding from the Sun, Geographos will again be at 1 AU from the Sun on July 31, but now preceding the Earth in its motion. Finally, the Earth will again overtake Geographos, resulting in a second opposition on 1976 October 11.

Geographos' extreme distances to the Earth will be as follows:

minimum: 0.385 AU on 1976 February 22
maximum: 0.413 AU on 1976 April 4
minimum: 0.271 AU on 1976 June 23

Oppositions of Geographos are not frequent. Here are the dates when Geographos and the Earth will have the same heliocentric longitude, from A.D. 1977 to 1994:

1979 Dec 12
1983 Feb 28
1983 Apr 11 (inf. conj.)
1983 Nov 3
1986 Dec 25
1990 Nov 17
1994 Jan 8

These dates have been calculated by the author, without taking perturbations into account; it is expected that they are not more than 1 day in error. Thus these are the dates in the near future when Geographos will be in opposition (in celestial longitude), except in April 1983 when the minor planet will be in inferior conjunction with the Sun. In 1983 we will have a situation similar to that of 1976: two oppositions and one inferior conjunction, although the configuration will not have the symmetry of that of 1976 (see the dates).

MINOR PLANET NEWS

Dr. David W. Dunham of Cincinnati Observatory reports that planet 1 Ceres (magnitude 7.0) will be occulted on 1976 January 13 around 2^h U.T. by an 80% sunlit waxing Moon as seen from a wide area of Latin America. The northern limit for this event crosses El Salvador, Southern Honduras, and passes near Guadeloupe in the Lesser Antilles. The southern limit passes near Arequipa, Peru; La Paz, Bolivia; and north of Rio de Janeiro, Brazil.

Planet 3 Juno will be occulted on 1976 February 16 around 22^h by a 98% sunlit waning Moon for observers in much of Africa and the Indian Ocean. Juno will be magnitude 8.8 at the time. The northern limit passes near the Strait of Gibraltar, northern Algeria, central Tunisia, northern Libya, northern Egypt, the northern Indian Ocean to the sunrise point west of Sumatra. The southern limit of the event passes south of Liberia, enters Africa just north of the equator, passes over southern Lake Tanganyika, the northern tip of Lake Nyasa, central Malagasy Republic, and goes south of Reunion and Mauritius Islands.

Unfortunately none of our present subscribers have addresses in these areas, but possibly some might be travelling in these areas at the time, or may have astronomer friends in these areas whom they might contact.

FOOTNOTES

PERSONAL. The Editor regrets not getting this second part of Vol. 3, no. 2 into subscriber hands much sooner. Due to a serious illness in the family, and heavy teaching responsibilities this past semester (five different courses) he has been hindered, and also fallen behind on correspondence. Your patience is appreciated. A lengthy issue with many promised articles of interest will appear (Lord willing) in 1976 January. Then we should be back on schedule.

THE MINOR PLANET BULLETIN is edited by Prof. Richard G. Hodgson, who is also ALPO Minor Planets Section Recorder. Subscriptions, changes of address and items for publication should be sent to him at Dordt College, Sioux Center, Iowa 51250, U.S.A. His home telephone is (712)-722-4081. Subscriptions are $ 3.00/yr; air mail overseas (highly recommended) $ 5.00/yr, U.S. funds preferred. If checked, your subscription expires ( ) with this issue; ( ) with next issue.