THE MINOR PLANET BULLETIN

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of the Association of Lunar and Planetary Observers

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AN OBSERVING PROGRAM FOR THE SERIOUS AMATEUR

By: Mark McConnell

Up until a few years ago the asteroids were a commonly neglected group of celestial objects suitable for amateur observing and a steady program of observation was carried out only by professionals and a small group of unorganized amateurs. Now, through the efforts of Dr. J.U. Gunter and, more recently, by the A.L.P.O. Minor Planets Section, this has all changed. It is in conforming to this change that I have written this article as a basic guide to those wishing to make tracking the minor planets their main observing program, as I have done. (See footnote by Editor at the end of this article).

The equipment necessary depends largely on your interest; binoculars can be used for the brighter planets, but their accuracy is poor. I have found that a 15 cm (6-inch) telescope can be used to observe about 30 to 40 planets brighter than photographic magnitude 13.5 each night. Considering that a good rate of observations is about six planets per hour, a 15 cm (6-inch) telescope certainly is adequate for a detailed and extensive program. (By the way, the most I have observed in one night is 27 asteroids). Although opinions vary, I prefer an equatorial mount, as such a mount provides for easy movement in right ascension and declination; this will prove a great convenience in the long run.

Magnification is another point to consider. You will want a wide-field yet you don't want skylight to prevent you from seeing the fainter stars. Even though I started with a 40mm eyepiece giving a field slightly over one degree across, I later found that a 20mm eyepiece with only a half-degree field to be better. I recommend, however, that you should use the lower power, wide-field eyepiece until you are used to using the charts and moving around the sky and then move onto a higher power, if necessary.

Star charts are another very important consideration. One of Hans Vehrenberg's photographic atlases should be considered indispensable. His Photographic Star Atlas (Falkau Atlas) goes to about 13th photographic magnitude and is perfect for a 15 cm (6-inch) telescope. For larger telescopes, Vehrenberg's Atlas Stellarum goes down to about magnitude $14\frac{1}{2}$ at twice the scale of the Falkau Atlas.[1]

Once a copy of the Ephemerides of the Minor Planets, the standard volume for both amateurs and professionals, has been obtained,[2] the paths of the selected planets can then be drawn on Xerox copies of the photographic charts. For locating the fields of the various charts an atlas such as Becvar's Atlas of the Heavens is quite useful.[3]

As you start observing you will soon find that quite often you will not be sure of a particular observation being accurate. There are reasons for this. For example, many of the brighter star images on the photographic charts are necessarily over-exposed causing many images to blend together. Thus it is hard to tell at times whether what you see through the telescope is a star or the planet for which you are looking. If this happens, just go back and check it again about two hours later. Unless the asteroid in in the process of reversing its direction (i.e., in one of the bends in its retrograde loop) you should be able to detect its motion quite readily if it is fairly close to some reference stars.

The major problem with this and many other observing programs is moonlight. For about a week or so around full Moon observing all but the brightest planets is virtually impossible, at least with a 15 cm telescope. Since this will tend to break up a consistent series of observations, you should plan accordingly.

Once you have completed your observations of a planet during a particular opposition, a record of those observations should be sent to the Minor Planets Section Recorder, Prof. R.G. Hodgson, using appropriate forms. It may also be a good idea to keep your own records of all observations. Here is one way: On an unruled sheet of paper, type, for each observation, the date, time, telescope aperture, power used, and measured position. Then tape onto the sheet the tracking chart which you used. By storing such sheets in a spiral notebook you can readily keep track of all your observations in a convenient way.

Though such a program may not be as valuable to science as variable star observing, there are occasions where it may be extremely important, as in the case of a planet found to be off its ephemeris position. In the meantime it is a very self-satisfying experience as well as being very educational. And, who knows, maybe you will even run across a new comet or similar phenomena while searching for some minor planet. Good luck!

Footnotes

1. Vehrenberg's Photographic Star Atlas costs $ 38.00 for edition A (black stars on white background) of the northern section, and $ 53.00 for edition B (white stars on black background). Edition A is recommended for asteroids. Atlas Stellarum North is priced at $ 103.00 and has black stars on white background. Both are available from Sky Publishing Corp., 49-50-51 Bay State Road, Cambridge, Massachusetts 02138, U.S.A.

2. The North American distributor for Ephemerides of Minor Planets is University of Cincinnati Observatory, Observatory Place, Cincinnati, Ohio, 45208, U.S.A. The price is $ 1.50 postpaid. (Note copies for the year 1974 are no longer available; the volume for 1975 should now be available -- Editor)

3. Becvar's Atlas of the Heavens, field edition (which is recommended) costs $ 4.00 per set. The deluxe edition is priced at $ 12.50. Both are available from Sky Publishing Corporation. (My only regret about the field edition is its omission of Flamsteed numbers, but its more compact format makes it easy to use -- Ed.)

Editor's Note: Mr. Mark McConnell thus far has been the most active observer in our A.L.P.O. Minor Planets Section, as a forthcoming report summarizing Section observations will make clear. He is an outstanding, mature observer in spite of being only 15 years old. He is now a junior class student at Horseheads Senior High School. Long interested in astronomy (which he plans to make his career), his 15 cm telescope is of his own making, and was completed in January 1972. With it he has observed all of the Messier objects, and approximately 100 different minor planets.

Mr. McConnell is evidence of what can be done with a 15 cm telescope in the minor planet field. Perhaps his example will encourage many others. Given the choice, of course, larger apertures are to be preferred since they permit observation of fainter planets (some of which may have special scientific interest), but larger apertures take longer to move from one part of the sky to another. The Editor doubts he could observe six planets an hour with his 41 cm (16-inch) f/7 Newtonian, especially if he had to keep adjusting ladders!

MINOR PLANETS AT HIGHLY FAVORABLE OPPOSITION IN 1975

By Prof. Frederick Pilcher

The following minor planets will be much brighter than usual at their 1975 oppositions. Observers are encouraged to note any that lie near the limit of their equipment, whether it be visual, photographic, or photoelectric. These planets should certainly be observed at the current apparition; 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 1975 Ephemerides of Minor Planets at opposition with the magnitude range in Tables of Minor Planets. Any planets whose perihelion and aphelion opposition magnitudes differ by 2.0 or more and in 1975 will be within 0.3 of the brightest possible have been included. For planets brighter than magnitude 13 and 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.
5	Astraea	Apr 19	10.5	503	Evelyn	Feb 7	12.7
9	Metis	Dec 10	9.1	510	Mabella	Jul 26	13.0
33	Polyhymnia	Jul 23	11.6	511	Davida	Feb 5	10.6
36	Atalante	Jan 26	12.5	530	Turandot	Oct 6	13.1
43	Ariadne	Jun 21	10.1	569	Misa	Dec 12	13.0
53	Kalypso	Nov 27	11.8	666	Desdemona	Sep 18	13.6
66	Maja	Oct 15	12.7	735	Marghanna	Nov 8	12.6
81	Terpsichore	Oct 11	12.2	746	Marlu	Jul 22	13.4
86	Semele	Dec 15	12.9	778	Theobalda	Dec 31	14.3
96	Aegle	Mar 17	12.3	791	Ani	Jul 22	13.8
97	Klotho	Sep 17	11.1	794	Irenaea	Jul 31	14.8
116	Sirona	Mar 24	11.4	849	Ara	May 14	12.5
130	Elektra	Sep 3	11.0	934	Thuringia	Sep 22	13.7
144	Vibilia	Aug 25	10.9	941	Murray	Sep 23	14.4
162	Laurentia	Jan 11	13.1	955	Alstede	May 20	14.0
164	Eva	Dec 1	11.3	969	Leocadia	Oct 20	14.8
188	Menippe	Aug 24	12.9	978	Aidamina	Nov 4	13.9
197	Arete	Sep 19	13.3	1056	Azalea	Aug 7	13.8
199	Byblis	Jul 4	13.2	1060	Magnolia	Jun 17	15.4
220	Stephania	Aug 15	13.1	1061	Paeonia	Nov 28	14.9
234	Barbara	Jul 3	11.9	1067	Lunaria	Nov 26	14.7
253	Mathilde	Jul 31	13.0	1090	Sumida	Jan 23	15.1
264	Libussa	Oct 27	12.7	1093	Freda	May 21	13.3
306	Unitas	Jun 7	12.0	1097	Vicia	Jun 11	14.8
314	Rosalia	Sep 26	14.2	*1125	China	Dec 5	17.5
333	Badenia	Sep 20	13.5	1165	Imprinetta	Jul 24	14.6
344	Desiderata	Jul 22	10.3	1168	Brandia	Oct 5	14.8
386	Siegena	Aug 17	11.5	1171	Rusthawelia	Nov 11	13.7
397	Vienna	Oct 21	11.9	1178	Irmela	Mar 23	15.1
406	Erna	Oct 14	14.1	1203	Nanna	Sep 24	15.5
415	Palatia	Jan 19	12.4	1310	Villigera	Sep 28	14.2
416	Vaticana	Apr 5	12.1	1314	Paula	Nov 21	15.3
419	Aurelia	Jun 16	10.8	1317	Silvretta	Nov 20	12.5
433	Eros	Jan 16	8.8	1386	Storeria	Aug 5	15.1
498	Tokio	Sep 23	11.8	1441	Bolyai	Sep 5	16.0

No.	Name	Opposition Date	Mag.
1463	Nordenmarkia	Nov 11	15.0
1473	1938 UT	Oct 4	15.2
1500	1938 UH	Nov 17	15.5
1530	1938 SG	Aug 20	15.7
1534	1939 BK	Jan 30	14.9
1536	1939 SE	Oct 11	15.3
1545	1941 UW	Feb 23	14.8
1547	1929 CZ	Dec 4	14.4
1568	Aisleen	Oct 19	14.2
1578	Kirkwood	Jan 20	16.0
1653	Yakhontovia	Sep 20	13.7
1660	Wood	Jan 29	14.9
1667	Pels	May 30	14.6
1707	1932 RL	Oct 9	14.7
1738	1930 SP	Jul 14	14.5

Notes. China, 1125, is very poorly observed and the published ephemeris may be greatly in error. Observers should be prepared to search the line of variation to find it. Perusal of this list will show a large number of planets with favorable oppositions in the fall season. This is an annual occurrence because a large number of asteroids have perihelia between heliocentric longitudes 330° and 60°; i.e., a perihelion opposition between late August and late November. This in turn can be explained in terms of the perihelion longitudes of Mars, 334°, and Jupiter, 14°. Asteroid orbits have the greatest stability if they avoid close approaches to the major planets. Therefore many asteroids have perihelia in roughly the same direction from the Sun as Jupiter's and Mars' perihelia.

Editor's Comment. Prof. Pilcher has once more performed a real service in preparing this listing of planets which will be coming to highly favorable opposition in 1975. Section members should attempt to observe as many of these planets as their instrumentation will allow, particularly giving attention to those which are fainter, and therefore less apt to be observed. Please note that the magnitudes given are photographic magnitudes. Observed visually most minor planets will be found to be about 0.8 magnitudes brighter than the photographic magnitudes, although the exact value will depend upon the planet's color.

OCCULTATION OF KAPPA GEMINORUM BY EROS

By Dr. David W. Dunham

J. Meeus, Erps-Kwerps, Belgium, and M. Gaven, Worcester Park, England, have pointed out that the 3.7-magnitude star Kappa Geminorum (Z.C. 1170, spectral type G5) will be occulted by the minor planet 433 Eros on 1975 January 24.02 U.T. Predictions by Brian Marsden reported in I.A.U. Circular No. 2695 shows that the path will begin north of Fargo, North Dakota; pass 3/5 of the way from Minneapolis to Duluth, Minnesota; very close to Wausau and Green Bay, Wisconsin; near Lansing and Ann Arbor, Michigan; between Akron and Cleveland, Ohio; near Pittsburgh, Pennsylvania; between Fredericksburg and Alexandria, Virginia; over Cape Charles, Virginia; over western Puerto Rico; about 50 km east of Caracas, Venezuela; across westernmost Brazil; and entering the Pacific about halfway between Lima and Arequipa, Peru. The estimated path uncertainty is 300 km, so the path might go over cities such as Minneapolis, Milwaukee, Detroit, Washington, Baltimore, Norfolk, San Juan, or Caracas. The path width is expected to be only about 15 km wide, with the occultation lasting perhaps as long as a tenth of a minute. An occultation of Kappa Geminorum's 8.2-magnitude companion (separation 7"0 in p.a. 238°) will occur some 1000 to 1500 km farther east.

During the next few months, the position of the predicted path will likely be improved with recent observations. As it stands, there is only about 1 chance in

20 that an observer in the vicinity of the path will see the occultation. We should try to spread as big a net as possible in order to catch the event. We should coordinate plans by defining several parallel tracks at 5-km intervals (these could be plotted on aeronautical charts of 1:500,000 scale) and make plans to have observers within 1 km of each of these tracks. If possible, we should have a few observers along each track, separated by perhaps 320 km (200 miles) along the track, due to the bad weather at that time of year. Clear areas in high pressure zones tend to be relatively small in January, but hopefully one set of observers will be in one. Observers should be equipped with a portable short-wave radio and tape recorder, and hopefully a cheap, simple photometer (plans for which will probably be published in a future issue of Sky and Telescope) attached to a telescope in order to get an accurate record of the event. Since the event will be easily visible with binoculars, and even the naked eye, amateurs might publicize the event in their area, showing an all-sky map and inset of Gemini to show how to locate the star. Timings might be made by many people by recording a pre-selected AM broadcast station, which could be calibrated with a WWV master tape, as we often do for grazes. But even without timings, observations by many people in a metropolitan area could pinpoint the path, and determine the width of Eros perpendicular to the path, very accurately. A lot of coordination at the regional and local level will be needed to take full advantage of this unusual opportunity.

Editor's Note. Dr. David W. Dunham is associated with the Department of Astronomy at the University of Texas in Austin, Texas. He is a leading expert on the subject of occultations as most readers of MPB are doubtless aware. All Section members who live near the path of this occultation should plan to participate, and should work to enroll others as Dr. Dunham suggests. Keep alert to publication of any improved predictions of the path of the event. There will doubtless be much written about 433 Eros during the next few months (cf. "Rendezvous with Eros", a fine article by J. Lawrence Dunlap in the 1974 October issue of Astronomy magazine). Dr. J.U. Gunter, editor of Tonight's Asteroids, is about to publish detailed tracking charts for Eros, copies of which will be sent to all MPB subscribers in the near future. Tracking this planet during this unusually favorable opposition and noting its light variations visually (up to 1.5 magnitudes) should prove to be highly educational for amateurs with modest equipment. Scientifically valuable work on Eros, however, requires capability to undertake high precision astrometry and/or photoelectric photometry. The only exception to that general statement is participation in the Kappa Geminorum occultation. Let's make the most of that opportunity.

MINOR PLANETS PASSING THROUGH VARIABLE STAR FIELDS

Observers lacking photoelectric photometry capability may wish to search for and observe minor planets which have sufficiently large light variations (about 0.4 magnitude or more) to be studied by means of visual variable star methods. This has been discussed in MPB 1, 33. While most minor planets will not prove to be suitable, it offers some scope for scientifically useful work for those with modest instrumentation. Planets 15 Eunomia, 18 Melpomene, 39 Laetitia, 43 Ariadne, and 433 Eros, for example, all have sufficiently large variations to be studied by this method, although in the case of most of these the rotation periods have already been fairly well determined.

Alain Porter and Frederick Pilcher have been working together to find moderately bright planets traversing star fields covered by AAVSO star charts. They find the following planets will be making close approaches to the variable stars noted:

No. Name of Planet	Dates (1974-75)	Variable Star: no., name, chart,			planet mag.
13 Egeria	Nov 9-19	0125+02	R Psc	b	$11^m.1$
563 Suleika	Oct 25- Nov 9	0214-03	Omicron Ceit	b	11.5
46 Hestia	Oct 20-30	0416+19	T Tau	b, c	11.6
68 Leto	Nov 29-Dec 9	0402+26A	TX Tau	d	11.3
		0402+26B	TV Tau	d	
247 Eukrate	Nov 19-29	0430+65	T Cam	b	11.4
14 Irene	Dec 14-Jan 23	0630+26	BR Gem	b	10.3
			KN Gem	b	
		0604+26	TU Gem	a	
39 Laetitia	Nov 24-Dec 9	0653+09	UY Mon	b	10.9

Regarding 39 Laetitia Prof. Pilcher comments as follows:

"The apparition of Laetitia offers considerable promise, since this object varies by half a magnitude, and additional data beyond the rather extensive data obtained over the past 20 years might enable the period of rotation to be pinned down to the nearest millisecond. Carl Veseley at LPL has been working on the rotation of Laetitia, but has had an undue amount of difficulty, and will welcome additional good quality data."

To be of scientific value observations must be made intensively every few minutes for as many hours at a stretch as possible, and preferably (weather permitting) for several nights in a row so that a number of rotations can be observed as fully as possible. A few scattered observations have little or no value. — RGH

SECTION NEWS

COMING SOON. As the discerning reader may have noticed vol. 2, no. 2 of MPB will be issued in more than one part. The Editor wishes to express his appreciation for the fine articles and observing reports which have been sent to him in recent weeks. The second part of vol. 2, no. 2 will include an important article on 887 Alinda by Edward F. Tedesco, and a report of intensive photoelectric photometry observations by Douglas Lindsay Welch and Rick Binzell resulting in a new rotation period for 18 Melpomene of 11^h50^m. (The mathematical reductions regarding Melpomene were undertaken by Joe Patterson, director of Camp Uraniborg, where the observations were made).

SUBSCRIPTION RATE INCREASE. The Minor Planet Bulletin Has had a $ 2.00 a year subscription rate since it was established in mid-1973. Our aim has always been to serve as a forum in which the professional research astronomer, the college science teacher and the serious amateur astronomer could share their discoveries, observations and insights concerning minor planets. We have always tried to publish suitable articles and papers with minimum delay, and at the lowest possible cost to the subscriber. Due in part to postage increases, and more significantly due to the fact that our issues are now about 40% longer than a year ago (which involves additional postage due to additional weight) it is necessary to increase the subscription rate to $ 3.00 a year, beginning 1974 December 1. We trust that our subscribers will understand, and appreciate the longer issues now being produced. Postage is our major expense, although we now have some off-set printing expenses as well. We could save money by rejecting articles, etc., but that would be a step backward as we are sure our readers will agree. We have also considered mailing by non-first class means, but that would greatly slow delivery. Since some of our information in almost every issue is useless if it arrives too late, we feel we must use first class mail. Thus the rate will become $ 3.00 a year beginning Dec. 1 Until then renewals and new subscriptions will be received at the old rate for one year only. Send to Prof. R.G. Hodgson, Dordt College, Sioux Center, Iowa 51250 USA.

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THE DENSITIES OF PALLAS AND VESTA AND THEIR IMPLICATIONS

By: Prof. Richard G. Hodgson

Abstract. Recent mass and diameter determinations indicate a density of about 3.0 grams/cm^3 for 2 Pallas, suggesting a silicaceous interior, and about 2.0 grams/cm^3 for 4 Vesta, indicating possibly an interior consisting of a mixture of silicaceous rock and water ice. Differences in their perihelic distances from the Sun and albedos may be responsible for the density difference between the two planets.

Early in 1974 Dr. Joachim Schubart of the Astronomisches Rechen-Institut of Heidelberg published new mass determinations for 1 Ceres and 2 Pallas. The implications of these findings for Ceres, which indicate an icy interior, have been discussed by the writer in an earlier paper (cf. MPB 1, 24-28). The present paper will give similar consideration to Pallas, and to Vesta, for which diameter and mass data are also available.

1. The Case of Pallas

J. Schubart (Astronomy & Astrophysics 30, 289-292 (1974)) gives the mass of 2 Pallas as $1.3 \pm 0.4 \times 10^{-10}$ Sun, or 2.587×10^{23} grams. This value we shall refer to as the probable mass, although there is admittedly a considerable measure of uncertainty present. The upper limit Schubart gives for the mass of Pallas is equal to 3.383×10^{23} grams; the lower limit is equal to 1.791×10^{23} grams. In view of the uncertainties involved these three different mass values will be considered in the discussion of density below.

The diameter of Pallas has not yet been well determined. One wishes that the occultation of 1973 February 6 had not been clouded out! (Cf. MPB 1, 4-5). A summary of the principal determinations is set forth by Cruikshank and Morrison in Icarus 20, 479. These values, expressed as diameters, and the resulting volumes (assuming Pallas is essentially spherical) are as follows:

Author(s)	Diameter	Volume
A. Dollfus (1971)	490 km	6.16×10^{22} cm^3
J. Ve veka (1973)	660 km	1.51×10^{23} cm^3
E. Bowell & B. Zellner (1973)	600 km	1.13×10^{23} cm^3
D.L. Matson (1971)	520 km	7.36×10^{22} cm^3
D. Cruikshank & D. Morrison (1973)	550 $\pm$ 50 km	8.71×10^{22} cm^3

Mean density is obtained by dividing mass by the volume. In this case we shall use Schubart's result for Pallas as "probable mass," but we shall also calculate the results if his upper or lower mass limits should prove to be correct. The mean densities for the diameters of the authors mentioned above are then as follows:

Author(s)		Using "Probable Mass"	Using "Upper Limit"	Using "Lower Limit"
Dollfus diameter	(490 km)	4.20 g/cm^3	5.49 g/cm^3	2.91 g/cm^3
Veverka "	(660 km)	1.72	2.25	1.19
Bowell & Zellner	(600 km)	2.29	2.99	1.58
Matson	(520 km)	3.51	4.60	2.43
Cruikshank & Morrison	(550 km)	2.97	3.88	2.05

Of course these mean densities are overprecise when carried to two decimal places, but they give a certain feeling for the subject. In general discussion they should be rounded to one decimal place.

The conclusion regarding the internal structure of Pallas points to a silicaceous rock composition, although, given the uncertainties in mass and diameter models involving heavy elements on the one hand, or water ice on the other extreme cannot be completely ruled out. The writer, however, is strongly inclined to take the moderate diameter of Cruikshank and Morrison and the probable mass given by Schubart as being most likely. If that is correct, the mean density of Pallas is 3.0 grams/cm^3, and its composition is probably largely silicaceous rock.

2. The Case of Vesta

The mass of planet 4 Vesta has been determined by H.G. Hertz (Science 160, 299-300 (1968)) to be 1.20 x 10^{-10} solar mass, based on study of a close orbital commensurability with planet 197 Arete, which approaches Vesta within 0.04 AU once every eighteen years. Expressed in other terms the mass of Vesta is 1.66 x 10^{23} grams.

Like Pallas, the diameter of Vesta has not yet been well determined. The principal determinations are given below, together with the volume which these values imply if Vesta is assumed to be spherical:

Author(s)	Diameter	Volume
A. Dollfus (1971)	420 km	3.88 x 10^{22} cm^3
J. Veverka (1973)	580 km	10.22 x 10^{22} cm^3
E. Bowell & B. Zellner (1973)	550 km	8.71 x 10^{22} cm^3
D.A. Allen (1971)	570 km	9.70 x 10^{22} cm^3
D.L. Matson (1971)	600 km	11.31 x 10^{22} cm^3
D. Cruikshank & D. Morrison (1973)	540 km	8.24 x 10^{22} cm^3

From these data the mean density of Vesta can readily be obtained for the various diameter values given. The results are as follows:

Dollfus	4.27 g/cm^3	Allen	1.71 g/cm^3
Veverka	1.62	Matson	1.47
Bowell & Zellner	1.90	Cruikshank & Morrison	2.01

As previously remarked such mean densities are overprecise when carried to two decimal places, and should be rounded off to one decimal place.

From the older, micrometrically determined values for the diameter of Vesta (represented here by Dollfus) a silicaceous planet containing some admixture of iron and other heavy elements is indicated. It is now increasingly clear, however, that the micrometric measures may underestimate the true diameter significantly. This problem has previously been discussed in relation to the planet Ceres by the writer in MPB 1, 26-27. On these grounds micrometrically determined measures of the tiny discs involved should be set aside, or, at best, be given limited weight in current discussions.

The other diameter determinations yield densities between about 1.5 and 2.0 grams/cm^3, or about the same as the best evidence seemed to be the case for Ceres (cf. MPB 1, 28). These densities are too low to permit a planet of purely silicaceous rock. Depending upon which particular density is used, the model will vary, but in all cases a significant amount of low density material — probably water ice — must be present. Until Vesta's diameter is better determined it would be unwise to speculate about the proportions of silicate rock and water ice involved.

3. Ceres, Pallas and Vesta Compared

It is perhaps worthwhile to consider some of the possible implications of the difference in density of Pallas as compared to that of Ceres and Vesta. It is likely that all three planets originated at approximately their present distances from the Sun in what is commonly called the asteroid belt. One would therefore expect that in the beginning they would have been rather similar in their internal composition.

Why does it appear today that Pallas is significantly denser than either Ceres or Vesta? Perhaps it is premature, in view of the uncertainties in the diameter and mass data, to entertain such a question. It does seem, however, that two factors — distance from the Sun and surface albedo — are clearly involved. These factors directly affect the surface temperature of planets. The density difference seems to depend upon the presence or absence of water ice in appreciable amounts in a permanently solid form over the age of the Solar System. (If the ice were to melt, even occasionally, the resulting water would work up to the surface where it would readily be lost into space; thus in time a planet's diameter could decline, and the mean density of its remaining materials could increase). The densities of these three planets may be highly significant, providing evidence for an "Ice Frontier" — a frontier which may fundamentally divide the Solar System into two parts. In the inner region of the Solar System permanent ice structures in the interiors of small planets are impossible because of solar heating. In the outer region, beyond the "Ice Frontier", permanent ice can exist in such planets, and is in fact an important component.

The evidence concerning the interiors of Ceres, Pallas, and Vesta is admittedly somewhat uncertain, but it clearly suggests that this "Ice Frontier" lies approximately between 2.1 and 2.5 AU from the Sun. Planets with perihelia within 2.1 AU are probably too warm to maintain permanently icy interiors. Beyond about 2.5 AU for perihelion distance many of the moderately large minor planets may contain a considerable amount of permanent ice. (The outer few km of such planets probably would not be icy due to heat generated by meteoroid impacts and the slow evaporation of any surface ice. For the same reason it is doubtful there would be much ice in small asteroids, even if they have remote perihelia and therefore constant cold temperatures).

At perihelion (when solar heating is maximum) Pallas is 2.1136 AU from the Sun. From the density data it appears to be somewhat on the inside of the "Ice Frontier" and may have lost much of its original interior ice. Ceres, on the other hand, has a perihelion distance of 2.5488 AU; its relatively low density suggests that it is slightly beyond the "Ice Frontier." Of course these values are subject to some variation with time, but not to a significant extent.

At first sight Vesta seems to present something of a problem. Its perihelion distance of 2.1528 AU is only slightly greater than that of Pallas, yet its mean density suggests it is more like Ceres in composition. The small difference in perihelion distance is not likely to be significant. More important is the fact that Vesta has an unusually high albedo (0.21) for a minor planet, compared with a more normal albedo for Pallas (0.08). (Cf. Cruikshank and Morrison, Icarus 20, 477-481 (1973)). Since Vesta is a much better reflector than Pallas it will reflect more solar radiation back into space, and will therefore be cooler. This doubtless would aid in ice retention. (Using a rather standard formula for the temperature of the illuminated hemisphere of planets without significant atmospheres (cf. Motz and Duveen, Essentials of Astronomy, p. 202) Vesta is found to be about 12° Kelvin cooler than Pallas when each is a perihelion. Local albedo variations could, of course, alter this result). This temperature difference may seem small, but it might prove significant in relation to the freezing point of water and the retention of interior ice.

(It will be of interest to see how this rather speculative investigation of minor planet interiors will hold up in the light of subsequent improvements in our knowledge. One important way in which some of the uncertainty can be removed is by occultation observations of these planets by Section members. Such observations are possible with modest equipment, and can lead to very accurate diameter determinations -- Editor).

THE ROTATION PERIOD OF 18 MELPOMENE

By: Douglas Welch, Rick Binzel

and Joe Patterson

Abstract: The results of photoelectric observations of minor planet 18 Melpomene are briefly reported. The period of rotation is found to be $11^h\ 50^m$, exactly five-sixths of the formerly reported value.

Minor planet 18 Melpomene came to a favorable opposition in August 197. In an effort to improve knowledge of its rotation characteristics, we made photoelectric observations totalling 14 hours over 4 nights. A rotation period of $14^h\ 12^m$ had been reported for this asteroid in 1962 by T. Gehrels and D. Owings (cf. Astrophysical Journal 135, 906), based on two nights of photoelectric observation in February and March 1958 which involved a separation of a full three weeks.

It is interesting that from spot observations of the asteroid in July and August we had detected a periodicity of 71 hours, and we assumed that this confirmed the old value of $14^h\ 12^m$ until we made the consecutive-night observations (involving 3 full nights) in August.

The telescope used was a 35.6 cm (14-inch) f/11 Schmidt-Cassegrain. The phototube was an uncooled 1P21 working with a conventional DC amplifier, with the numbers read from a microammeter. All observations were done at Camp Uraniborg, a summer camp in astronomy and physics located near Big Bear Lake, California, U.S.A., at an elevation of 2,250 meters (7,400 feet). Observing conditions at Camp Uraniborg are generally excellent with extremely dark night skies prevailing, and excellent seeing and transparency being the general rule. During the three consecutive full nights of observation the same comparison star was used since it remained within one degree of the planet.

Now that 18 Melpomene has been observed during 2 oppositions photoelectrically, it is possible to determine roughly the direction of the rotation axis. Since the asteroid varied by 0.35 magnitudes in 1958, and by only 0.18 magnitudes in 1974, it is clear that the rotation axis must have a fairly high inclination (if the axis were perpendicular to the ecliptic, the variation would always be the same). The longitude can also be determined to lie near 150°, so that this asteroid reinforces the case for alignment of asteroids' rotation axes (cf. T. Gehrels and D. Owings, Astrophys. J. 135, 906 (1962)).

It is expected that a more detailed discussion of these observations of 18 Melpomene will be published in a major astronomical journal. Discovery of the new rotation period underlines the importance of closely spaced observations.

EDITORS NOTE: Messrs. Welch, Binzel and Patterson are to be commended for their fine work on 18 Melpomene. All are subscribers to MPB, and we are happy that the attention given to observing Melpomene in Dr. Gunter's Tonight's Asteroids and in these pages of MPB prompted their investigation and discovery.

In a letter to the Editor, Joe Patterson, Director of Camp Uraniborg, wrote the following:

"I want to emphasize that this project was conceived and executed entirely by amateurs, and the two observers (Douglas Welch and Rick Binzel) were 15 year old high school students. Although few amateurs have access to photoelectric equipment, construction of a photometer is a feasible project for many clubs... A photometer transforms any telescope into a powerful research instrument, and a tremendous wealth of observing opportunities opens up. When you have run out of asteroids, you can always start in on the stars..."

For intending photoelectric observers Mr. Patterson recommends Photoelectric Astronomy for Amateurs by Frank B. Wood, and Manual of Photoelectric Photometry published by the American Association of Variable Star Observers, Cambridge, Massachusetts, U.S.A. in 1967.

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SECTION NEWS

1974 MA (OBJECT KOWAL). Many Section members responded to the appeal made in July for observations of planet 1974 MA (known preliminarily as "Object Kowal"). This fast-moving minor planet with an Earth-crossing orbit has its perihelion near the orbit of Mercury, and therefore is of special interest. Unfortunately the appeal came at a time when many of our observers were away on vacation. For example, Prof. Pilcher of Illinois College was climbing in the Rocky Mountains; Mark McConnell was away in Florida. Ed Tedesco reported from New Mexico that an extended period of bad weather hindered his efforts completely; much the same problem was encountered in July in the Washington D.C. area according to June LoGuirato. Alain Porter in Narragansett, Rhode Island thought that he had found 1974 MA one night, but a check of the area later showed that he had found "Object Porter" instead, which, according to Dr. Brian G. Marsden was an unidentified asteroid with a more normal orbit. "Object Porter" was not seen again unfortunately. Other observing attempts were made by some of Joe Patterson's crew at Camp Uraniborg with negative results. John Allcock, Director of Observations of the Montreal Centre of the Royal Astronomical Society of Canada, also organized search observations to no avail. For a time there was fear that the planet might slip away without an adequate series of observations to determine its orbit and permit future recovery. The Recorder spent several nights in fruitless searches with his 41 cm and 32 cm Newtonian reflectors. It was a very frustrating experience. Finally word came (cf. IAU Circulars 2688 and 2696) that the 122 cm Schmidt telescope at Mt. Palomar had obtained two more observations. The latter of these also indicated why 1974 MA had been missed by so many observers -- it was approximately two magnitudes fainter than had been predicted, and could therefore have easily been overlooked. Improved orbital elements were published in IAU Circular 2705. An ephemeris based on these elements was published in IAU Circular 2709 covering the period 1974 Nov. 29 through 1975 Apr. 18. During that period, however, 1974 MA will be photographic magnitude 19.5 or fainter, and therefore beyond the instrumentation of most of our subscribers.

433 EROS. Planet 433 Eros will be making an unusually close approach to the Earth in 1975 January as Section members are doubtless aware. As indicated in MPB 2, 14-15 Eros will occult the bright star Kappa Geminorum on 1975 January 24.02. Recent precise positions for Eros suggest that this event may be visible farther to the east than the path indicated by Dr. Dunham. Doubtless further revisions in the predicted path of this event will be made as the date approaches. Tracking charts for 433 Eros have been made available by Dr. J.U. Gunter for the benefit of Section members and their friends, and are included with this mailing. His kindness is much appreciated.

Regional Co-ordinators for the Eros occultation of Kappa Geminorum are being set up. More details will be given in the next issue.

947 MONTEROSA. Dennis Bohn of Mount Horeb, Wisconsin, U.S.A. reports that planet 947 Monterosa is somewhat off the predicted position. On 1974 Nov. 12.09 the planet was located at $2^h 59^m.0$ R.A., + 16° 53' declination (1950.0 coordinates). This is about $1^m.1$ in R.A. west and 5' declination south of its predicted position. More observations are requested. The uncorrected published ephemeris is as follows for the next few weeks:

1974	R.A. 1950.0	Dec.
Nov. 19	$2^h 52^m.3$	+ 16°59'
Nov. 29	2 44.2	+ 17 08
Dec. 9	2 38.7	+ 17 24
Dec. 19	2 36.5	+ 17 47

THE NEXT ISSUE. The next issue of MPB (vol. 2, no. 3) should appear in early December, somewhat early in view of the fact that the Recorder-Editor will be away on a visit to New England during the period December 18 - January 15. Due to space limitations the article of Edward F. Tedesco on 887 Alinda has been deferred to this next issue.

SUBSCRIPTION RATE INCREASE. As previously indicated beginning 1974 December 1 the subscription rate for The Minor Planet Bulletin will become $ 3.00 US a year. Until then renewals and new subscriptions at the old $ 2.00 rate will be received for one year only.

Items for publication and subscriptions (payable in U.S. funds) should be sent to the Editor, Prof. Richard G. Hodgson, Dordt College, Sioux Center, Iowa 51250, U.S.A. He is also the A.L.P.O. Minor Planets Section Recorder, and can usually be reached at night at his home telephone (712)-722-4081.