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CCD PHOTOMETRY OF 466 TISIPHONE

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CCD observations were made of 466 Tisiphone on four nights in August and September 1997. The synodic period of rotation was found to be 8.824 ± 0.009 hours and the observed lightcurve had an amplitude of 0.114 ± 0.011 magnitudes.

Observations

The asteroid 466 Tisphone is a C-type asteroid (Tholen, 1989). Its orbit has a semi-major axis of 3.36 AU. The observations of 466 Tisiphone we report here were made at the Paul Feder Observatory, located on the Buffalo River Site of the Moorhead State University Regional Science Center. This facility is 15 miles east of Moorhead, Minnesota (Fargo, North Dakota) and is adjacent to the Buffalo River State Park. Data were collected the nights of August 27, August 30, September 1, and September 5, 1997.

The observatory has a 16-inch computer controlled Cassegrain telescope made by DFM. The associated Photometrics Star 1 CCD camera system was used to collect data. In all, 163 images were made of the asteroid during the four nights. Of these, 131 were used in the analysis. The others were rejected because the asteroid image was too close to a star image or because they were taken too close to dawn.

The exposures were 3 minutes long and typically separated by 10 minutes. No filter was used. Dark current and flat field corrections were made to the data. Five stars were used as magnitude standards for each image. The magnitudes were taken from the Guide 2 program (Hubble Guide Star Catalog). A least squares fit was done for each image and the relation between the magnitude and the log of the total count determined. The magnitude of the asteroid was then determined from this relationship. A photometric aperture of 7 pixels radius, corresponding to about 11 arcseconds, was used and an equal sized region of background nearby used for the background correction.

Results

Times were corrected for travel time from the asteroid to the Earth and were taken to be at the mid-times for the images. Lightcurves were made for each of the four nights. Relative magnitudes from night to night were uncertain as different comparison stars were used. This was dealt with by using additive constants for the second, third and fourth night magnitudes to bring them into agreement with the first night. A single lightcurve for the four nights was then least squares fit to a Fourier series including eight harmonics. The additive constants for the second through fourth nights and the period were then adjusted so that the fit minimized the sum of the squares of the residuals. The resulting values were a period of 8.824 ± 0.009 hours, the additive constant for the second night was 0.111, for the third night was -0.068, and for the fourth night was

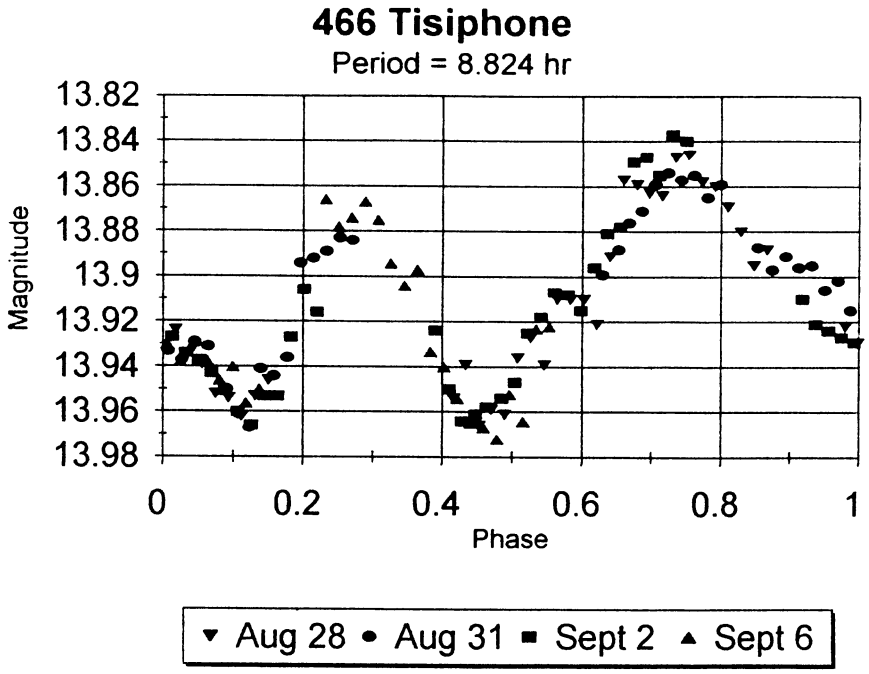

Figure 1. Composite lightcurve for 466 Tisiphone assuming our solution period of 8.824 hours. Zero phase corresponds to 0 hours UT on August 28, 1997. The magnitude scale is on the photometric system of the Hubble Guide Star catalog and must be considered to be uncertain by ± 0.40 magnitudes in its overall calibration. However, the point-to-point relative magnitudes are uncertain only by about ± 0.009 magnitudes.

0.078 magnitudes. These are reasonable as the uncertainties in the Hubble Guide Star Catalog are given to be about ±0.4 magnitudes. The standard deviation of the residuals was 0.009 magnitudes which should be a good measure of the uncertainty in the relative magnitudes.

A period of 8.824 hours was assumed and the second through fourth night data were translated to fall on the first night data to give the composite lightcurve shown in Figure 1. The time scale is given in rotational phase with the zero corresponding to 0 hr on August 28, 1997 UT. There are clearly two maxima and two minima per rotation. The amplitude of the light curve is 0.114 ± 0.011 magnitudes. The phase angle during the observations varied between 7.2° and 8.6°.

Acknowledgments

The authors would like to thank A. W. Harris for his help with some of the data analysis.

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ASTEROID AND PLANET CLOSE ENCOUNTERS

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The well-known case of 1997 XF11 and its Earth encounter in Oct. 2028 raised public attention to the danger posed by Near-Earth Objects (NEOs). Astronomers also realized that discovery and follow-up of this kind of object is the primary step toward mitigating the hazard. As soon as the orbital parameters have been obtained from observations, the computation of the Minimum Orbital Intersection Distance (MOID) gives some information about the orbital distance between asteroid and planet orbits. (Bowell and Muinonen 1994; Bowell 1995; Carusi and Dotto 1996).

Sormano Observatory has been involved since its foundation, ten years ago, in astrometric measurements of such objects. Recently software to obtain the MOID from the first set of measurements has been developed in order to plan additional astrometric observations (Sicoli and Manca 1996; Matarazzo 1997) and eventually to compute real planetary encounters (Sicoli 1997). Two separate lists that include close approaches of asteroids to the inner planets have been then compiled and both are accesible through the net (Sicoli and Manca 1998).

The first one is named the Minor Body Priority List (MBPL). This list refers only to the Earth encounters for three centuries: one hundred years in the past (could be useful to search precovery images as 1997 XF11 demonstrated) and two hundreds years in the future. As a rule of thumb, we list, as potentially dangerous, the bodies (H magnitude less than or equal to 22) having an Earth MOID distance lower than the following thresholds (as a function of the timespan covered by the astrometric observations available):

Observation arc or no. of oppositions	Earth MOID limit (AU)
Asteroids	
from 3d to 30d	0.074
from 31d to 60d	0.064
from 61d to 3 opp.	0.044
4 or more opp.	0.014
Periodic Comets	0.084

Predicted minimum separation is computed (Testa, 1998), just for those bodies with at least 2 months arc, starting from the MPC orbital solution, and including perturbations by all the planets (except Pluto) and the Moon as a separate body. Finally some tests have been carried out in order to compare the accuracy of the results with other sources (Yeomans and Chodas 1994; Chodas 1998).

An integer number, suggesting just a rough estimate of the accuracy of date and close approach prediction, has the following meaning:

(1) good
(2) quite good
(3) uncertain
(4) very uncertain

As of mid-August 1998, 96 unnumbered and 19 numbered minor planets (plus 10 comets) are included. For 68 of these, minimum separation with our planet is listed. Table I presents a examples of MBPL entries for the case of 1998 DV9 and (2340) Hathor.

The second list we have prepared is called the Planetary Close Encounters List (PCEL). The PCEL catalogues only multi-opposition minor planets with a MOID-Planet lower than 0.02 a.u. The objects have been selected from the orbit intersection page (Koehn and Bowell 1998) and the minimal distance from Mercury, Venus, and Mars has been calculated with the same software. Table II presents an interesting PCEL example detailing the next close approach between minor planet 1991 VE and Mercury. It should be noted that since we have not considered relativistic effects and especially because of uncertainties in the orbital elements (obtained just from two oppositions), slight differences could occur from these results.

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TABLE I. Examples of Minor Body Priority List entries for two asteroids. The full list is available at: http://www.brera.mi.astro.it/sormano.html

Object	Earth MOID (A.U.)	H	Opps	Arc	Predicted Earth encounters Date	Min.Dist. (A.U.)	
1998 DV9	0.003	18.0		(154)	1917-02-03	0.010	(4)
					1975-01-30	0.005	(2)
					2005-01-11	0.076	(2)
					2028-02-18	0.065	(3)
					2058-02-12	0.042	(3)
					2095-02-11	0.042	(4)
					2146-01-18	0.055	(4)
(2340)	0.006	19.2	5		1921-10-20	0.010	(1)
					1952-10-22	0.067	(1)
					2014-10-22	0.048	(1)
					2045-10-21	0.024	(1)
					2069-10-21	0.007	(1)
					2086-10-22	0.006	(2)
					2113-10-23	0.039	(3)
					2130-10-23	0.019	(3)
					2194-10-23	0.006	(4)

TABLE II. Example entry for the Planetary Close Encounters List for Mercury and 1991 VE. The full list is available at: http://www.brera.mi.astro.it/sormano.html

Object	Mercury MOID (A.U.)	H	Opps	Arc	Predicted Close encounters Date	Min.Dist. (A.U.)
1991 VE	0.001	18.5	2		2006-10-23	0.006
					2030-04-16	0.017
					2051-05-15	0.021
					2074-11-05	0.010
					2094-03-27	0.008
					2116-01-13	0.008
					2135-06-04	0.011
					2157-03-20	0.015
					2176-08-10	0.007

SUGGESTED REVISED H VALUES OF SELECTED ASTEROIDS

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We report 18 minor planets for which extensive visible or CCD measurements indicate a suggested revision of their catalogued H magnitudes. For the majority of these, the suggested revision is 0.5 magnitude, or more.

Throughout 1998, the Magnitude Alert Project (MAP) has continued to grow in both membership and observations received. MAP now includes 19 members in 5 countries. The work of MAP has expanded to now include asteroids found to have apparent magnitude discrepancies by the Minor Planet Section from 1990 to 1996, as well as newly discovered asteroids apparently discrepant since the founding of MAP in 1997. Our MAP Database actually contains observations for each object observed since May 18,1998 and will be extended to the objects observed in 1997 and in the beginning of 1998. It is managed by both Gerard Faure (for the network AUDE in France) and Lawrence Garrett.

Observations for the following asteroids have lead to suggested revised H magnitude values. The revised absolute magnitude H is the average of the mean magnitudes calculated for each night of observation. These values are based on both visual and CCD measured magnitudes. Comparison objects used for estimates were USNO catalog stars, Hubble catalog stars, and other asteroids without know magnitude errors. A range of possible H values based on all observations submitted is also included. Full details on these observations will appear in the General Report of observations for 1998 by the section coordinator Prof. Frederick Pilcher.

Asteroid and Observers	Current H Mag	Revised H Mag	Number of Observations	H Mag Range
982 Franklina Claude Boivin Lawrence Garrett	9.9	9.3	4	9.3
1155 Aenna Gerard Faure Lawrence Garrett	11.5	11.8	4	11.8-11.9
1178 Irmela Pierre Antonini Claude Boivin Robin Chassagne Bernard Christophe Lawrence Garrett	11.8	11.4	9	11.3-11.6
1384 Kniertje Pierre Antonini Gerard Faure Jean-Marie Llapasset Rene Roy Stephano Sposetti	9.7	11.1	16	10.9-11.4
1449 Virtanen Pierre Antonini Gerard Faure Lawrence Garrett Alain Klotz Jean-Marie Llapasset Rene Roy Stefano Sposetti	12.4	11.9	27	11.4-12.4
1909 Alekhin Pierre Antonini Gerard Faure Roger Harvey	12.3	12.9	6	12.7-13.1
2939 Coconino Pierre Antonini Roger Harvey	12.6	13.2	4	13.0-13.5
3198 Wallonia Gerard Faure Lawrence Garrett Tom Laskowski	12.3	13.2	3	13.1-13.5
3904 Honda Pierre Antonini Bernard Christophe Gerard Faure Roger Harvey Jean-Marie Llapasset Philippe Martinole	11.3	11.7	27	11.2-12.1
4709 Ennomos Pierre Antonini Claude Boivin Robin Chassagne Gerard Faure Lawrence Garrett Rene Roy	8.9	8.5	15	7.9-8.7
5641 Mc Cleese Pierre Antonini Roger Harvey Philippe Martinole Rene Roy	12.7	14.0	10	13.3-14.4

Asteroid and Observers	Current H Mag	Revised H Mag	Number of Observations	H Mag Range
6009 1990 FO1	12.3	12.6	40	12.6-13.1
Pierre Antonini Robin Chassagne Gerard Faure Sergio Foglia Roger Harvey W.Marinello Gianopaolo Pizzetti Rene Roy Stefano Sposetti Brian Warner				
6249 Jennifer	12.4	12.7	4	12.7-13.2
Maurizio Bignotti Sergio Foglia Lawrence Garrett Tom Laskowski Gianopaolo Pizzetti				
7778 1993 HK1	12.5	13.1	8	13.0-13.2
Sergio Foglia Lawrence Garrett Frederick Pilcher Gianopaolo Pizzetti				
8201 1994 AH2	16.3	15.9	40	15.2-16.5
Pierre Antonini Claude Boivin Robin Chassagne Gerard Faure Lawrence Garrett Rene Roy Stefano Sposetti				
9083 1994 WC4	11.9	12.4	5	12.1-12.8
Pierre Antonini Gerard Faure Roger Harvey				
1987 OA	18.5	17.3	9	16.9-17.5
Stefano Sposetti Rene Roy				
1998 OP	22.0	21.5	46	21.3-21.7
Claude Boivin Gerard Faure Lawrence Garrett Roger Harvey Tom Laskowski				

Asteroids found to be only variable, but more research needed.

1025 Riema	0.4 mag ?	16 measures
1476 Cox	0.6 mag ?	18 measures
3913 Chemin	1.0 mag	20 measures

CALL FOR OBSERVATIONS

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Observers who have made visual or photographic measurements of positions of minor planets in calendar 1998 are encouraged to report them to this author on or before April 15, 1999. This will be the deadline for receipt of reports which can be included in the "General Report of Position Observations for 1998," to be published in *MPB* Vol. 26, No. 3.

Observers who contribute precise photographic or micrometric positions are requested to pay careful attention to the precision of their measurements. The *Minor Planet Bulletin* will continue to publish reasonably good astrometry generally accurate to 10 arcseconds or better, but henceforth we must require a reliable statement of the standard deviation of the observation set. Individual researchers then can decide whether a particular set of observations meets their needs. The number of reported significant digits should not exceed the standard deviation of the data set. Random errors of measurement can be determined by remeasuring a random sample of photographic positions several times. Some grasp of the systematic errors on a photograph can be obtained by measuring and reducing the positions of some catalog stars along with the minor planet images. The reduced positions can then be compared with those in the catalog. Alternatively, every catalog star on the photograph can be used in a least squares reduction scheme, and the residuals in the star positions should be indicative of the expected residuals in the minor planet positions.

ASTEROID PHOTOMETRY OPPORTUNITIES MAY-JULY

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The table below lists asteroids that come to opposition during the months of May through July that represent useful targets for photoelectric or CCD photometry observations. Observations are typically needed because the asteroid has either an unknown or ambiguous rotational period. The table gives (in order of opposition dates) the asteroid number and name, opposition date, opposition V magnitude, the rotational period (in hours), the estimated lightcurve amplitude (in magnitudes), and the designation PER if observations are needed to determine the rotational period. AMB implies that previous period determinations have given ambiguous results and these alternate periods are listed in the table. Question marks are used to denote uncertain or unknown values.

Now that many amateur and other small observatories have CCD capabilities, much fainter targets are accessible to them. Therefore, we have included a selection of fainter targets, down to opposition magnitude 15. Our emphasis among these fainter targets is to reach to the smallest size bodies possible within that magnitude limit. Thus the objects listed tend to be inner-belt asteroids, or even Mars or Earth-crossing objects, at unusually favorable oppositions. To achieve this, we filter the list of all oppositions to include those objects with H (absolute) magnitude >14.0 (roughly <5 km in diameter), but opposition V magnitude <15.0, and then further eliminate any objects for which adequate observations have already been made. Our criteria for the brighter objects remains the same: opposition V magnitude <12.0 and that the period is unknown, very uncertain, or ambiguously determined. We have dropped low phase angle as a criterion for inclusion, as it seems no one has responded to past listings suggesting phase relation observations.

Ephemerides for any solar system object can be calculated with the HORIZONS program; see the web page at http://ssd.jpl.nasa.gov/ . Finder charts for some of these asteroids may appear in the *Minor Planet Observer*. For information on this publication, contact: Brian D. Warner, 17995 Bakers Farm Rd., Colorado Springs, CO 80908; brianw_mpo@compuserve.com .

Asteroid	Opp'n Date	Opp'n V Mag	Per	Amp	
120 Lachesis	May 3	11.8	>20?	0.1	PER
275 Sapientia	May 5	11.9	?	?	PER
172 Baucis	Jun 1	11.8	>16	0.2	PER
105 Artemis	Jun 9	11.2	16.8? 37.1?	0.2	AMB
56 Melete	Jun 12	10.5	13.7? 18.1?	0.1	AMB
50 Virginia	Jul 11	12.0	14.3?	0.2	PER
7216 1977 QQ2	Jul 23	14.8	?	?	PER

Asteroid Photometry Opportunities

THE MINOR PLANET BULLETIN (ISSN 1052-8091) is the quarterly journal of the Minor Planets Section of the Association of Lunar and Planetary Observers. The Minor Planets Section is directed by its Recorder, Prof. Frederick Pilcher, Department of Physics, Illinois College, Jacksonville, IL 62650 USA, assisted by Lawrence Garrett, 206 River Road, Fairfax, VT 05454 USA (LGASTEROID@aol.com). The *MPB* is edited by Dr. Richard P. Binzel, MIT 54-410, Cambridge, MA 02139 USA (rpb@astron.mit.edu), and is produced by Dr. Robert A. Werner, JPL MS 301-150, 4800 Oak Grove Drive, Pasadena CA 91109 USA (robert.a.werner@jpl.nasa.gov). Derald D. Nye serves as the Distributor.

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* * * * *

The deadline for the next issue (26-3) is May 1, 1999. The deadline for issue 26-4 is August 1, 1999.