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EARTH CLOSE APPROACHES OF MINOR PLANET (7482) 1994 PC1

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Minor planet 1994 PC1 was discovered at Siding Spring on frames taken by R. H. McNaught on the night of Aug. 9, 1994. The discoverer was also able to find previous single night observations from 1974, 1977 and 1980 allowing G.V. Williams at the Minor Planet Center to compute a quite accurate orbit. (Williams, 1994). The orbital elements suggested that 1994 PC1 was an Apollo-type object with a period of 1.56 years. In the last apparition, early this year, the minor planet reached the minimum distance from us on Jan.20 (0.065 AU) and with more additional precise positions a definitive number was assigned (Williams, 1997). Indication about possible close approaches of asteroids and comets to the planets can be obtained computing the minimal distances between the orbits (Sitarski, 1968).

The Earth-MOID (Minimum Orbital Intersection Distance) value in particular indicates the minimum separation between the osculating orbits of our planet and another interplanetary object. This is also the closest possible approach of the two bodies if they reach the 'MOID-point' at the same time. In order to plan follow-up observations of near-Earth objects, software was developed to check Earth-MOID values from a preliminary orbit (Sicoli and Manca, 1996; Matarazzo G., 1997). The same program was then run for well-kwown asteroids revealing that (7482) 1994 PC1 is actually the numbered minor planet with the smallest Earth-MOID parameter (0.00043 AU).

It should be noted that a small MOID value does not necessarily involve a real past or future close approach (e.g. in case of orbital resonance). The MOID also changes owing to planetary perturbations. Fig. 1 shows the MOID variation for (7482) 1994 PC1 ranging from 4 to 14 Earth-radii in about 30 years.

Following these indications, close approaches of this asteroid and the Earth were computed taking into account perturbations by all planets (except Pluto) and the Moon, as a separate body. The results are summarized on Table I; the minimum separation, in a six hundred years time scale, seems to have occurred on Jan.17, 1933 when the object, at magnitude 9, passed only 1.1 million km from the Earth.

References

Matarazzo G. (1997). private communication

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Sitarski G. (1968). "Approaches of the Parabolic Comets to the Outer Planets", Acta Astron. 18, 171.

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Table I. Earth close approaches of (7482) 1994 PC1

Year	Distance (AU)
1699	0.010
1710	0.067
1790	0.047
1801	0.009
1842	0.010
1853	0.031
1922	0.084
1933	0.007
1997	0.065
2022	0.013
2069	0.070
2105	0.015
2130	0.081
2194	0.028
2255	0.063
2280	0.016

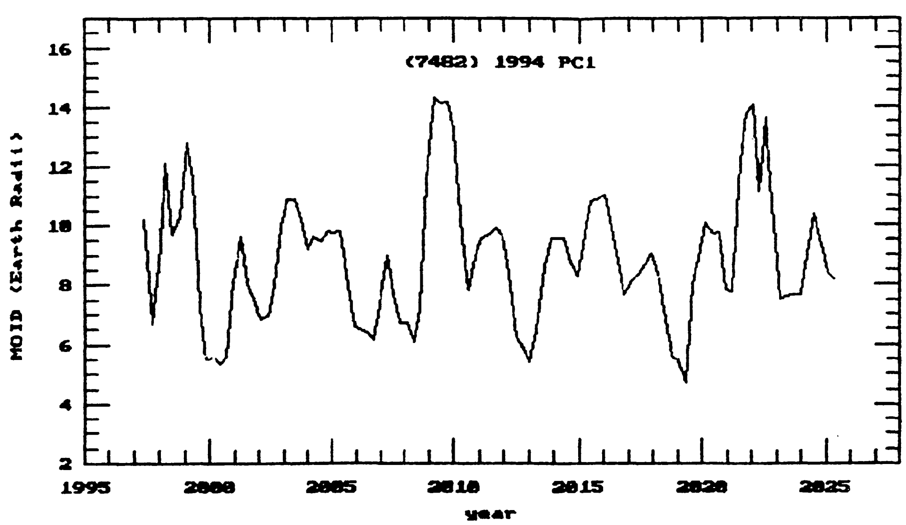

Figure 1. Minimum Orbital Intersection Distance (MOID) for (7482) 1994 PC1.

PHOTOMETRIC OBSERVATIONS OF MINOR PLANET 402 CHLOE

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Photometric observations of minor planet 402 Chloe were made in January through March of 1997 to determine its rotational period and lightcurve amplitude. A period was not determined. The amplitude of the lightcurve for this opposition was found to be less than 0.1 magnitudes, less than expected. The reduced magnitude for zero phase angle was determined to be 8.45 ± .10 magnitudes, brighter than expected.

Introduction

Minor planet 402 was recommended for observation by Harris and Zappalà (Harris and Zappalà 1997). The amplitude was expected to be greater than 0.2 magnitudes. In 1989 Richard Miles of the British Astronomical Association found the period greater than 10 hours (correspondence with Alan Harris).

Observations

The asteroid was observed January 16th, 30th, 31st, February 1st, 17th, March 3rd, 8th, and 13th Universal time.

Images were taken at five minute intervals without filtration with a 25 cm. F4.5 newtonian scope located in Corpus Christi Texas. The detector was a SBIG ST6 operating at -15 deg. C. All 171 images were dark subtracted at the time of exposure with separate unique dark fields. Flat fielding was done later with a master flat made from a seven image average.

17 images were rejected due to clouds or blurry stars. Nightly calibration was made to six Hubble guide stars appearing in the field with the minor planet. Differential photometry was performed on each image using the same Hubble guide stars as reference stars. The magnitude determined from each image was averaged with the magnitudes from the adjacent images to minimize instrumental noise. Each night's lightcurve was converted to reduced magnitude and the apparent midpoint of the nightly lightcurve was plotted against the phase angle. Observations made on 1/30/97 were extremely noisy due to high clouds and were thrown out.

An effort was made to investigate possible systematic errors in the phase curve arising from different plate to plate calibrations of the original Palomar survey from which the Hubble Guide Star Catalogue was made. From an index map of the Palomar plates (Deen, 1992) it was found the Hubble Guide stars used span three separate Palomar plates. An obvious inaccuracy in my magnitude estimates occur between the last two nights observations plotted on the phase curve. The Hubble Guide stars used those two nights were present on the same original Palomar plate. Observations made between 8 and 10 degrees of phase angle were made with stars on two different Palomar plates. They show good agreement. Only the two low phase angle observing runs were in the part of the sky covered by the third plate, POSS plate #62.

If there is a systematic error in Guide Stars from that plate then the apparent phase coefficient could appear more in the normal range instead of between -0.1 to 0.1. With seven nights observation from 0.6 to 18.6 degrees of phase angle it does not appear possible for the phase coefficient to be high enough or the mid-curve magnitude errors large enough for the reduced magnitude to be dimmer than 8.7. The reduced magnitude for zero phase angle more likely falls into the 8.4 to 8.6 range this opposition.

Results

A period determination was unsuccessful. However the phase curve plot indicates the asteroid does not have a high amplitude light curve if the period is long. On no evening was the amplitude of the light curve greater than 0.07 magnitudes. The phase curve plot combined with the lightcurve on 1/31/97 indicate the light curve amplitude to be no greater than 0.1 magnitudes. The phase curve plot would show much greater scatter if the asteroid had a high amplitude and long period. An extrapolation of the phase curve plot suggests the minor planet has a reduced magnitude for zero phase angle of 8.45 ± 0.1 magnitude this opposition.

References

Harris, A.W., and Zappalà, V. (1997). "Asteroid Photometry Opportunities" January-March Minor Planet Bulletin 24, 1.

Harris, A.W. e-mail communication 2/21/97

Deen, G.W. (1991). "Microsky News" December 1991.

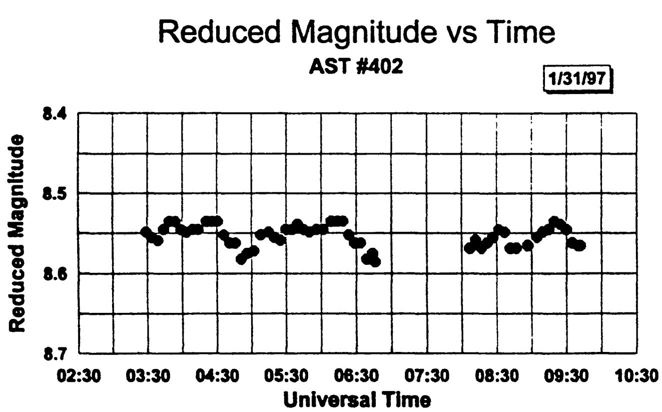

Figure 1. Lightcurve of minor planet 402 Chloe 1/31/97. The Y axis is reduced magnitude for 1.1 degree phase angle referenced to six Hubble Guide stars.

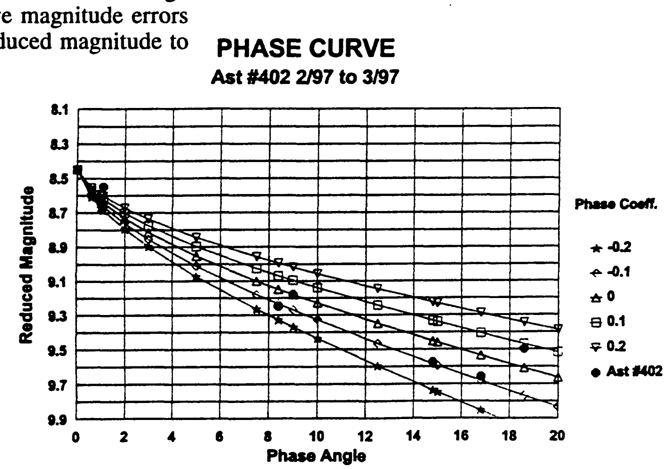

Figure 2. Phase Curve of Minor Planet 402 Chloe 1/97-3/97. The Y axis is reduced magnitude. The X axis is phase angle.

ASTEROID PHOTOMETRY OPPORTUNITIES

NOVEMBER-JANUARY

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The table below lists asteroids that come to opposition during the months of November through January 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 all of the asteroids in the table are included in this issue. Finder charts for some of these asteroids may appear in the Minor Planet Observer. For information on this publication, contact: Brian D. Warner, Box 818, Florissant, CO 80816.

Asteroid	Opp'n Date	Opp'n V Mag	Per	Amp	
203 Pompeja	Nov 5	12.0	46.6 or 23.3	0.1	AMB
415 Palatia	Nov 5	11.3	?	?	PER
177 Irma	Nov 25	11.8	?	?	PER
1992 AB	Dec 18	14.9	?	?	PER
1139 Atami	Jan 2	13.4	>20	>0.1	PER

Asteroid Photometry Opportunities

DATE	R.A. (2000) HR	MIN	DEC. DEG	MIN	MAG V	PHASE ANGLE
Minor Planet 177 Irma						
1997 Oct 19	4	30.17	+23	53.0	12.7	18.7
29	4	26.86	+23	55.8	12.5	14.5
Nov 8	4	20.32	+23	49.3	12.3	9.7
18	4	11.54	+23	33.4	12.0	4.4
28	4	1.89	+23	9.9	11.9	1.6
Dec 8	3	52.94	+22	42.8	12.2	6.7
18	3	46.08	+22	17.4	12.6	11.4
28	3	42.14	+21	58.2	12.9	15.5
1998 Jan 7	3	41.48	+21	48.2	13.1	18.8
Minor Planet 203 Pompeja						
1997 Sep 29	3	4.45	+20	50.5	12.9	15.6
Oct 9	3	0.05	+20	51.1	12.7	12.2
19	2	53.18	+20	39.1	12.4	8.2
29	2	44.54	+20	14.9	12.2	3.9
Nov 8	2	35.17	+19	41.4	12.1	2.0
18	2	26.30	+19	3.3	12.3	6.0
28	2	19.01	+18	26.5	12.6	10.2
Dec 8	2	14.09	+17	56.4	12.8	13.9
18	2	11.94	+17	37.2	13.0	16.9
Minor Planet 415 Palatia						
1997 Sep 29	3	17.69	+ 3	53.2	12.2	19.9
Oct 9	3	17.77	+ 2	55.4	11.9	16.4
19	3	14.69	+ 1	55.9	11.6	12.5
29	3	8.93	+ 1	3.1	11.4	9.1
Nov 8	3	1.46	+ 0	26.5	11.3	8.0
18	2	53.73	+ 0	14.2	11.4	10.5
28	2	47.19	+ 0	30.3	11.6	14.5
Dec 8	2	43.05	+ 1	14.8	11.8	18.6
18	2	42.02	+ 2	23.9	12.1	22.1
Minor Planet 1139 Atami						
1997 Nov 28	7	6.73	- 1	30.5	13.6	29.7
Dec 8	7	4.35	- 4	53.0	13.4	25.9
18	6	57.84	- 7	26.8	13.3	22.5
28	6	48.80	- 8	55.8	13.3	20.4
1998 Jan 7	6	39.47	- 9	13.6	13.4	20.1
17	6	32.08	- 8	27.5	13.6	21.4
27	6	28.10	- 6	54.0	13.9	23.8
Feb 6	6	28.24	- 4	52.1	14.2	26.3
16	6	32.46	- 2	39.6	14.5	28.6
Minor Planet (1992 AB)						
1997 Nov 8	6	27.98	+ 2	59.4	17.1	23.8
18	6	26.38	+ 5	19.6	16.7	20.9
28	6	20.25	+ 8	44.8	16.2	16.4
Dec 8	6	8.78	+13	31.3	15.6	10.1
18	5	51.70	+19	41.5	15.0	2.3
28	5	29.81	+26	50.0	15.1	7.7
1998 Jan 7	5	5.56	+34	3.7	15.4	17.1
17	4	42.69	+40	32.1	15.7	25.4
27	4	24.75	+45	54.7	15.9	31.9