were used. This was dealt with by using an additive constant for the first and another for the third night magnitudes to bring them into agreement with the second night. A single lightcurve for the three nights was then least squares fit to a Fourier series including ten harmonics. The additive constants for the first and third 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 10.636 ± 0.015 hours, the additive constant for the first night was +0.048 and for the third night was +0.215. 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 10.626 hours was assumed and the first and third night data was translated to fall on the second night data to give the composite light curve shown in Figure 1. There are clearly two maxima per period. The minima are narrow and asymmetric. The amplitude of the light curve is 0.258 ± 0.012 magnitudes. The phase angle during the observations varied between 8.80° and 9.40°.

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CCD PHOTOMETRY OF 16 PSYCHE

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CCD observations of the asteroid 16 Psyche were made at the NF/Observatory at two different oppositions. Exposures were made on nine nights in May and June, 1993. Additional exposures were made on UT August 14, 1994. The spin vector was determined using the amplitude and magnitude method. The calculated pole position was found to be near ecliptic latitude 9 degrees and longitude 222 degrees. Additionally, a Vmax of 5.80 at the minimum assumed aspect angle was derived. This is 0.2 magnitude less than reported from the 1973 opposition.

Introduction

16 Psyche is a well studied main-belt asteroid listed as M-class with a rotational period of 4.196 hours. Its lightcurve amplitude varies from 0.03 to 0.42 magnitudes (Lagerkvist *et al.* 1989). Previously published pole positions for the spin vector have varied in ecliptic longitudes between 215 and 225 degrees and ecliptic latitudes from 4 to 55 degrees (Magnusson 1989). The synodic period of 16 Psyche has made observations at opposition possible only at four heliocentric longitudes; (near 70, 160, 220 and 310 degrees). This fact has increased the uncertainty on pole position calculations. Favorable data taken over ten nights at N/F Observatory possibly narrows the pole latitude solution.

Observations:

Exposures were made through a Johnson V filter on a CRAF-Cassini 1024x1024 CCD. The pixel size is 1.2 arc seconds. The chip and amplifier floor noise is 27 electrons. Full well is 100,000 electrons. The telescope is a 0.45-m Newtonian. Control of the observatory was done by radio link and has been described elsewhere (Neely 1989).

Differential photometry was used between the asteroid and comparison star within the same field. Exposures were made for 80 seconds. Data reduction and analysis was accomplished using PCVISTA (written by Michael Richmond at Berkeley). After the centroids of the asteroid and comparison stars were found, an aperture of 8 arc seconds was integrated, and an annulus was used for computing and subtracting the sky background. The V magnitudes were all transformed to the standard system.

16 Psyche was imaged with differential comparison stars on 1993 UT dates 4/27, 5/1, 5/2, 5/3, 5/11, 6/4, 6/5, 6/6 & 6/7. During this apparition, a heliocentric longitude of about 228 degrees presents the lowest lightcurve amplitude variation. Star 4383-0434 (Guide Star Catalogue) was imaged on May 3, 1993 and was used for calibration of the comparison stars. Star 4383-0434 had previously been studied for calibration of photometry for S.N. 1993j (de Vaucouleurs 1994). Accurate calibration of photometry was further insured by the negligible color difference between 16 Psyche and the calibration star. Time variable extinction was calculated by plotting a curve of the calibration star and comparison stars. Additional photometry of comparison stars in all fields were then used to calibrate instrumental V magnitude to the standard magnitude system.

On August 14, 1994 UT, 16 Psyche was imaged at heliocentric longitude 314 degrees and presented a high photometric amplitude. Calibration frames were made using Landoldt 112-275. The airmass difference between the comparison and calibration stars was negligible.

Results

The observational circumstances for the two apparitions are shown in Table I and include Vmax reduced to standard distance to determine V(1,0) using a G value of 0.21. It should be noted that on UT 5/11/93, 16 Psyche was at heliocentric longitude of 228 degrees and yielded an absolute magnitude of 5.80 which is brighter than previous measurements. It is possible that data contained within this paper represent the most favorable observational circumstances to determine Psyche's polar aspect angle.

Using data from observations cited and previously published sources, Taylor *et al.* (1976), Tedesco *et al.* (1982,1984), Lupishko *et al.* (1982), Pfleiderer *et al.* (1986), Zhou *et al.* (1982) and Weidenschilling *et al.* (1987), Psyche's pole position was calculated by the amplitude-magnitude method. A north pole longitude of about 228 degrees is in general agreement with past research. However, the north pole latitude is more difficult to determine.

Previously published pole positions vary as much as 51 degrees in latitude. Latitude designations widely vary for a number of reasons. First, the ecliptic plane and pole latitude are in apparent proximity. Due to this proximity, small errors in the variation of Vmax amplitude produces wide results

using the amplitude-magnitude method. For instance, a latitude of 37 degrees could be explained by an amplitude variation of 0.07 magnitude. Additional latitudes have been derived using the epoch method. Although the epoch method has the advantage of not being phase angle dependent, two varying solutions for pole position are inherently produced.

Opportunities to gather data for the pole position of 16 Psyche have been limited due to an orbital period of 4.99 years and synodic period of about1.25 years. Using the amplitude-magnitude method demands a phase angle of <15 degrees (Magnusson *et al.* 1989). Using the epoch method, Tedesco *et al.* found a pole longitude and latitude of 223 and 37 degrees respectively, but Tedesco chose not to use data taken by Lupishko *et al.* (1982) on May 5, 1978 due to incongruities in the reported lightcurve. However, a minimum variation in amplitude of 0.03 ± 0.005 reported by this paper is in agreement with Lupishko *et al.* A solution of 8.7 ± 5 degrees in pole latitude is further strengthened by the superimposed lightcurves of three nights of data shown in Figure 1.

Finally on UT 14 August 1994, 16 Psyche offered an opposition at heliocentric longitude of 314 degrees. A V magnitude amplitude of 0.32 ± 0.05 was observed on this date. These data are published as part of a spectroscopic study of Psyche (Binzel et al. 1995). The shape of 16 Psyche was derived from this large amplitude and the minimum amplitude variation of 0.03 ± 0.005 mentioned above. The resulting axial ratios for Psyche are: a/b=1.35, b/c=1.29, a/c=1.76.

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Table I. Observational Circumstances

UT Date	Ecliptic Longitude	d	r	Phase Angle	V Max	V(1,0)
4/27/94	226° 01′	2.26	3.25	3.4°	10.56	. . .
5/01/93	226° 39′	2.25	3.25	2.8°	10.54	. . .
5/02/93	226° 49′	2.25	3.25	2.6°	10.38	. . .
5/03/93	226° 58′	2.25	3.25	2.4°	10.32	. . .
5/11/93 *	228° 14′	2.25	3.24	2.0°	10.27	5.80
6/04/93	232° 04′	2.32	3.23	9.8°	10.80	. . .
6/05/93	232° 14′	2.33	3.23	10.1°	10.78	. . .
6/06/93	232° 24′	2.34	3.23	10.5°	10.79	. . .
6/07/93	232° 33′	2.34	3.23	10.9°	10.85	. . .
8/14/94	314° 19′	1.71	2.71	2.0°	9.62	6.13

*UT 5/11/94 used for extrapolation of V(1,0)

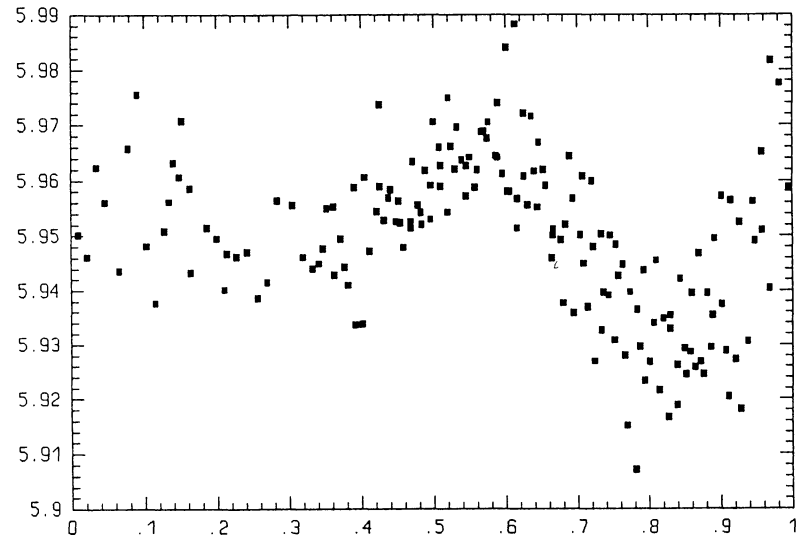

Figure 1. Low amplitude lightcurve of asteroid 16 Psyche as measured on 1993 UT Dates May 1,2, and 3. This low amplitude helps constrain the pole position of Psyche to an ecliptic latitude near 9 degrees.

PHOTOELECTRIC PHOTOMETRY OF 16 PSYCHE AND 40 HARMONIA

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Photoelectric photometry observations of asteroids 16 Psyche and 40 Harmonia were made in the second half of 1994. The observed amplitudes were about 0.35 and 0.13 magnitudes, respectively, and their measured rotation periods are consistent with their tabulated values.

Throughout mid-to-late 1994, asteroids 16 Psyche and 40 Harmonia were favorably positioned for photometry work. The photometric measurements were made at Holtsville, NY located on Long Island approximately 55 miles east of New York City. The observations were made using an Optec SSP-3 solid state photometer coupled to a 20-cm Schmidt-Cassegrain telescope. All observations reported here were made through a clear filter. The goal of these observations was to check the rotation period and lightcurve amplitudes of these asteroids.

Observations

Asteroid 16 Psyche was discovered in 1852 and has an estimated diameter of 247 km. It has an orbital period of almost exactly five years, thus presenting the same lightcurve aspect every five years. For example, Weidenschilling et al. (1987) reported observations in 1984 at nearly the same aspect. We achieved very similar results. My observations for the night of UT August 7, 1994, shown in Figure 1, reveal a surprisingly large amplitude of 0.35 magnitudes. Apparently, this date provided a very nearly equatorial aspect for observing Psyche. For the photometry, a V magnitude 7.6 comparison star was used that was located about one-half degree southwest of Psyche. Psyche's next apparition will be in November and December 1995. At that time it will have a more pole-on aspect and this author will re-observe Psyche in expectation of a minimum amplitude.

40 Harmonia was discovered in 1856 and has an estimated diameter of 112 km. The "Photometry Opportunities" column in *MPB* **21**, No. 4 listed Harmonia as a candidate for shape and pole modeling. Observations were made on UT November 26, 1994 and UT December 3, 1994 using two different comparison stars within one-half degree of Harmonia. Unfortunately the November 26 observations were cut short due to high clouds rolling in. A more reliable lightcurve was obtained on December 3. Results are shown in Figure 2. The observed amplitude is 0.15 magnitudes and the lightcurve is consistent with the published period of 9.136 hours. Observational circumstances for both asteroids are presented in Table I.

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I want to thank Alan W. Harris of JPL for providing me with additional information on 16 Psyche.

Table I

Asteroid	UT Date	R.A.(1994)	Dec.	Ecliptic Long.	Ecliptic Lat.	r (AU)	delta (AU)	Phase Angle
16 Psyche	Aug 7 1994	20:49	-16.04	309.6	1.58	1.71	2.72	1.61
40 Harmonia	Nov 26 1994	3:54	+16.02	59.2	-4.17	1.22	2.20	2.46
	Dec 3 1994	3:46	+15.56	57.4	-3.88	1.23	2.21	5.80

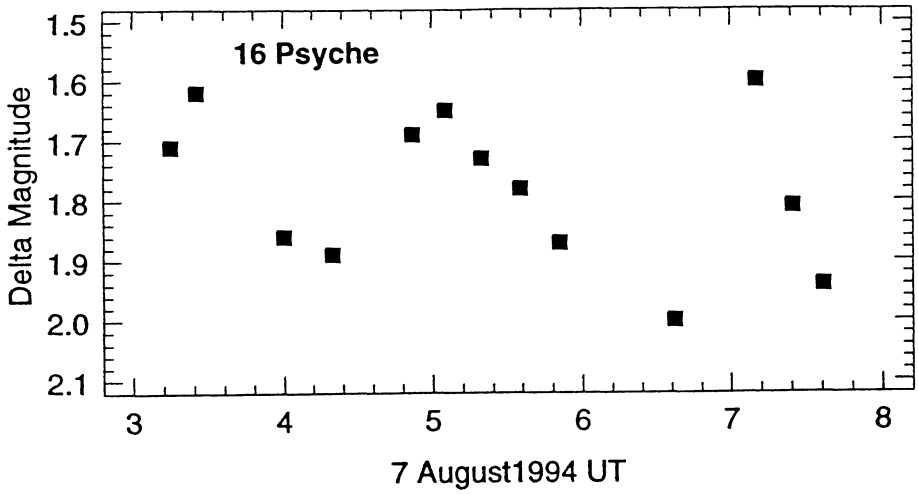

Figure 1. Photoelectric lightcurve of asteroid 16 Psyche.

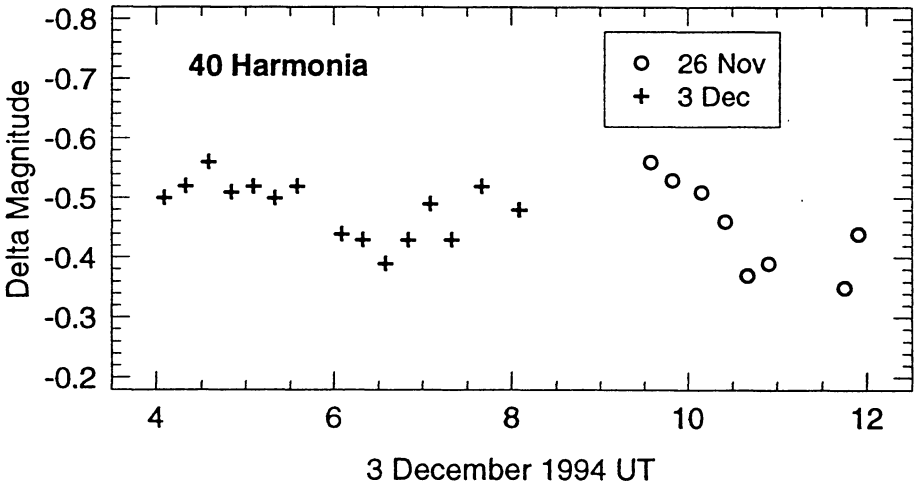

Figure 2. Photoelectric lightcurve of asteroid 40 Harmonia. The data from 26 November have been shifted in time assuming the published period of 9.136 hours. The vertical shift is arbitrary to match the levels of the maxima.

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