THE 13 NOVEMBER 1984 OCCULTATION OF BD +08°0471 BY (1) CERES

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INTRODUCTION

The 13 November 1984 occultation of BD+08°0471 was discovered during a photographic search carried out with the 0.5-meter Carnegie Double Astrograph at Lick Observatory and the Lowell Observatory PDS microdensitometer (Millis et al. 1984). Such a search was stimulated by the curious fact that few favorably located occultations of AGK3 or SAO catalog stars by Ceres will occur during the 1980s. The occultation on 13 November, however, is a particularly good event. The star is $10^{m}.3$ in V, yielding a predicted drop at occultation of about 10%. Such a drop can be detected by small telescopes equipped with photoelectric photometers, but is too small to be seen visually. The track was predicted to cross the Caribbean, Florida, southern Texas, and Mexico. Based on this prediction, we prepared to observe the event in Mexico using four portable occultation data systems.

DATA SYSTEM AND RECORDING TECHNIQUE

One of the three Lowell Observatory portable occultation observing systems is shown in Figure 1. It consists of a C-14 Celestron telescope and a two-channel photometer. The signals from the two photomultipliers are amplified and recorded on two channels of a four-channel cassette data recorder. A 1000-Hz signal is recorded on the third channel to provide a stable time base, independent of variations in tape speed. The fourth channel is used to record WWV time signals, providing an absolute time reference. The data from one photometer channel are also displayed on a dual pen strip chart recorder along with a one-second time tick. The strip chart gives an on-line visual record and also provides redundancy should the cassette recorder fail. The entire system is portable and is powered by a small gasoline motor generator. The fourth observing system was provided by the University of Maryland. It is similar to that shown in Figure 1, except that the data system is based on an Apple II microcomputer.

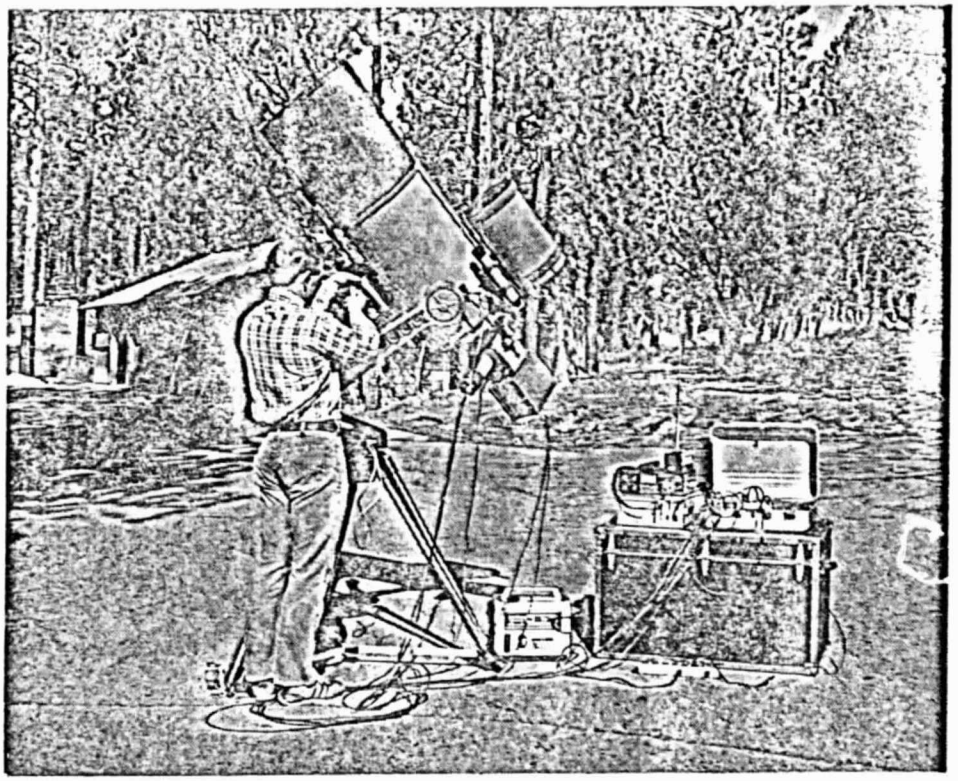

Figure 1. Portable telescope, two-channel photometer, and data recording system: The telescope is a Celestron C-14 with a C-8 mounted on it as a finder. The two-channel photometer on the rear of the telescope is equipped with an uncooled blue-sensitive and cooled red-sensitive photomultiplier tube. The open suitcase-like box on the packing case contains the two high-voltage power supplies, the voltage-to-frequency converters, the DC amplifiers, as well as the 1000-Hz and 1 Hz time reference signals. The stack to the left of the suitcase contains the WWV timecube, the cassette recorder, and the strip chart recorder. The motor generator is sitting on the ground next to the packing case.

OBSERVATIONS AND RESULTS

We sent the four observing teams into Mexico by truck to observe the 13 November occultation. These teams set up observing stations at the following sites (Figure 2): South of Culiacan, near Cicalahua (Site No. 1); San Blas (Site No. 2); Puerto Vallarta (Site No. 3); and Chamela (Site No. 4). Although the Puerto Vallarta site was clouded out, the occultation was successfully observed at the other three sites. A typical tracing of the event as seen at the San Blas site is shown in Figure 3. As expected, the drop in the signal at occultation is small, but easily detectable.

Figure 2. Map of the southwestern United States and the west coast of Mexico showing the locations of our four observing sites.

Using standard techniques (Wasserman et al. 1979) we have derived from our observations the lengths of three chords across Ceres. These chords are shown in Figure 4 along with the best-fitting circular limb profile of the asteroid. The actual ground track, derived from the fit, is shown in Figure 5. Based on this solution, we find that Ceres has a circular profile with a diameter of 945 ± 6 km. This value shows that an estimate by Johnston, Seidelmann, and Wade (1982) for the diameter of Ceres of 818 ± 82 km, based on radio observations, is seriously in error, while the radiometric determination of 953 ± 50 km by Brown et al. (1982) is relatively accurate. A more recent radiometric determination (Lebofsky, personal commmunication) of 962 km is also in good agreement with the occultation result.

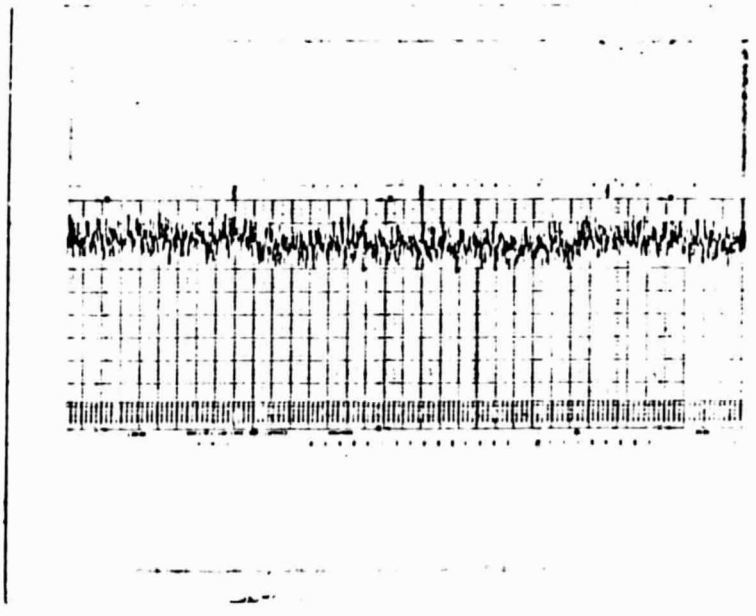

Figure 3. A portion of the strip chart of the Ceres occultation recorded at San Blas. The occultation is clearly visible, although quite shallow. The one-second time ticks are at the bottom of the chart.

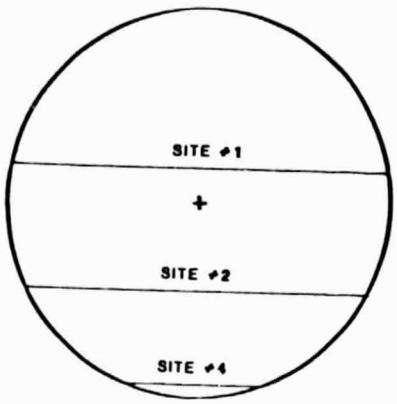

Figure 4. The best-fitting circular profile to the three chords obtained by our expedition. The resulting diameter is 945±6 km.

Figure 5. The after-the-fact ground track. This track is the one determined from the fit shown in Figure 4. Consequently, it shows where the occultation actually occurred.

Combining the occultation diameter of Ceres with the asteroid's mass of $5.9\pm0.3\times10^{-10}M_{\odot}$ (Schubart and Matson, 1979) yields a bulk density of 2.7 ± 0.1 gm/cm^3, the error being dominated by the error in the mass. Consequently, the density of Ceres is very similar to that found earlier for Pallas (Millis and Elliot, 1979). We expect that both objects are primarily composed of rocky material and that, as expected, the figure of Ceres is determined by its self-gravitation; the strength of the material is not sufficient to support large-scale departures from a spherical equilibrium shape over the age of the solar system.

Finally, adopting a value of 3.63 for V(1,0), the occultation diameter yields a geometric albedo of 0.069, typical for C-type asteroids.

This occultation was also observed at nine other sites in Mexico, Florida, and in the Caribbean by teams from the Massachusetts Institute of Technology, the Lunar and Planetary Laboratory, the Florida Institute of Technology, and the University of Florida. A full analysis including all of the observations is currently in progress. However, it is apparent that the results will not significantly differ from those presented here.

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