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Occultation Binaries Observed from KPNO: Astrometry Corrections Using the Observed Rate of Lunar Motion

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1. INTRODUCTION

Lunar occultation data often are reduced by means of a multiparameter least-squares fitting routine. For binary stars the minimum number of free parameters is five: the time of geometric occultation for each star, the intensity of each component, and the background intensity. From these values the magnitude difference between components can be calculated as well as the angular separation of the binary in the direction perpendicular to the lunar limb (i.e. the lunar position angle). If the observed rate of motion of the lunar limb can be determined as an additional free parameter, then the difference between observed and predicted values can be interpreted in terms of a local lunar slope. Therefore, in principal the observed rate of motion can be used to correct the vector separation — both angular separation and direction — of the binary. In this paper four occultation binaries observed from KPNO are examined to determine whether binary-star astrometry can be improved using these corrections.

2. OBSERVATIONS

The selected binaries come from the summaries of Schmidtke *et al.* (1989, 1992). Table 1 identifies the systems and lists relevant occultation results, including both uncorrected and corrected vector separations. All binaries have a history of visual measurements (cf. Aitken 1932), which has been supplemented with recently published observations. Three of the systems also have been observed using speckle interferometry (cf. McAlister & Hartkopf 1988).

TABLE 1. Occultation results for binary stars.

ADS	Date	ΔV or Δy (mag)	$\rho^a_{\rm uncor}$ (mas)	$\theta^a_{\rm uncor}$ (°)	$\rho^b_{\rm cor}$ (mas)	$\theta^b_{\rm cor}$ (°)
2253	1988.6691	0.210 ± 0.016	304.7 ± 0.3	27.0	315.4 ± 3.0	30.0 ± 0.9
2616 AB	1989.1200	0.037 ± 0.045	26.6 ± 0.3	92.2	25.9 ± 0.4	98.0 ± 1.7
3608 AB	1986.2833	2.049 ± 0.051	261.8 ± 0.4	39.1	326.6 ± 2.7	52.2 ± 0.6
5234	1989.1284	1.538 ± 0.074	604.4 ± 0.7	302.9	...	...

[a] uncorrected results — calculated using the predicted rate of lunar motion.
[b] corrected results — calculated using the observed rate of lunar motion.

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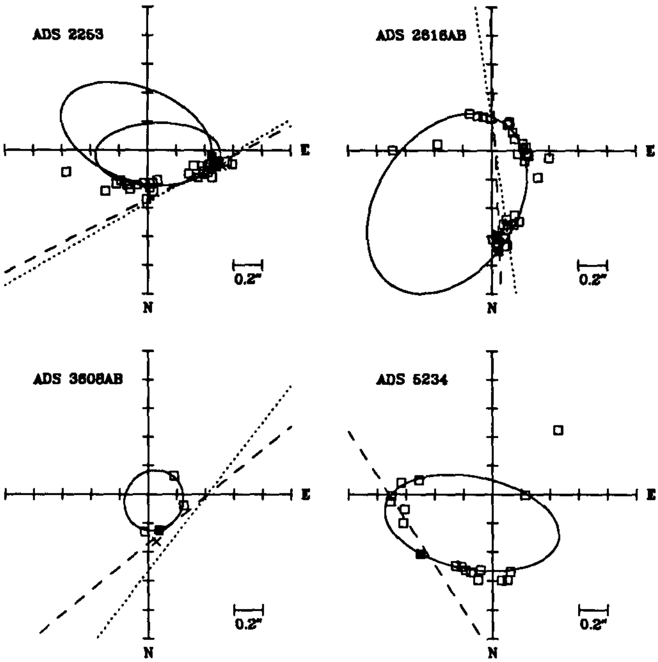

FIGURE 1. **Astrometry of occultation binaries.**

The astrometry of each binary is shown in Figure 1, where visual observations are marked by open squares and speckle data by crosses. The calculated orbits, using elements tabulated by Worley & Heintz (1983), are indicated by ellipses, with the predicted position of each secondary star at the time of lunar occultation represented by a filled square. The occultation results are shown by straight lines since these data measure the separation only in a specific direction. A dashed line shows allowed positions of the secondary using uncorrected occultation results while a dotted line indicates the positions for data that have been corrected for the observed lunar rate. A qualitative goodness of fit is obtained by comparing the occultation results with contemporaneous speckle data. In general the corrections do not yield an improved astrometric fit.

2.1. ADS 2253

Published visual measurements of the position angle for this long-period system often differ by ±180° although recent speckle observers routinely adopt the SW quadrant. Because the 1988 occultation unambiguously places the secondary in the NE quadrant, the discordant measurements and the orbital ephemerides have been adjusted accordingly. Alternative orbits are shown, corresponding to two sets of available elements (Worley & Heintz 1983). Both lines representing the occultation results are consistent with recent speckle and visual measurements, indicating that there is no advantage to using the corrected occultation data.

2.2. ADS 2616 AB

Although Δm is very small for this system, all non-occultation position angles agree with the 1989 occultation measurement. Unfortunately, the position angle of the lunar limb during this event is almost perpendicular to that of the binary so that corrections to the occultation data have a large tangent-arm effect. The uncorrected occultation results are preferred.

2.3. ADS 3608 AB

The uncorrected results from the 1986 occultation clearly are superior to the solution with corrections.

2.4. ADS 5234

The rate of motion of the lunar limb during the 1989 occultation of this binary could not be calculated. Hence, only a single line is drawn, showing the uncorrected results. It is doubtful that significant improvement would result from the use of corrected occultation data.

3. DISCUSSION

When the rate of lunar motion is determined, it is sensitive to a very small segment of the lunar limb. For each binary considered here, the projected linear size of an individual stellar disk at the distance of the moon is <1 m and the projected length corresponding to the occultation fringes used to calculate the lunar rate is typically ~ 16 m (Schmidtke *et al.* 1989). In contrast the projected linear separation between components is much larger. Hence, they disappear or reappear at different positions along the lunar limb. Estimates of linear separations for these occultations range from <200 m for ADS3608AB to ~ 1000 m for ADS2616AB. Unfortunately, these values are unobtainable from occultation data alone, but require an assessment of the spatial aspects of the binaries as shown in Figure 1. Since the estimated linear separation of each binary is significantly larger than the characteristic length used to determine the rate of motion, it is not surprising that corrections based on a small segment of the lunar limb cannot be applied to the much larger projected linear separation of the binary.

4. REFERENCES

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