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MEASUREMENT OF DOUBLE STARS BY OCCULTATION WITH SMALL TELESCOPES

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1. Introduction

Hydrographic Department of Japan makes observations of occultation as routine at its three branch observatories in the country. The purpose is to obtain the value of ΔT which is needed for the compilation of almanacs. About 800 data including 100 photoelectric observations are obtained every year (e.g. Sinzi, 1971). Observation data are published annually in the *Data Report of Hydrographic Observations, Series of Astronomy and Geodesy*. A few photoelectric records show events for double stars, i.e. double disappearance or reappearance. If same event is observed at two or more stations, or occultations of same star are observed at different epochs, relative positions of components of double star can be determined. Present report describes briefly some examples of such observations.

2. Stations and Equipments

Locations and equipments of three stations are as follows:

Sirahama Hydrographic Observatory, (Code No. 5)

$\phi = +34°42'46''.65$, $\lambda = -9^h15^m57^s.360$, $h = 171.9$m

Telescope: Equatorial Cassegrain reflector, $\phi = 30$cm, $f = 500$cm.

Simosato Hydrographic Observatory, (Code No. 6)

$\phi = +33°34'23''.86$, $\lambda = -9^h03^m45^s.655$, $h = 57.9$m

Telescope: Equatorial Cassegrain reflector, $\phi = 30$cm, $f = 500$cm.

Kurasiki Hydrographic Observatory, (Code No. 7)

$\phi = +34°35'23''.38$, $\lambda = -8^h55^m05^s.023$, $h = 4.9$m

Telescope: Equatorial Cassegrain reflector, $\phi = 30$cm, $f = 1000$cm.

In these observatories, EMI 6094 B photomultipliers are used without filter and cooling, maximum voltage being 1450. Amplifiers are AC-conversion type DC amplifiers, whose gains are 10^5 and frequency characteristics are DC$\sim$100 Hz (+5 to -10%). Inkoscillographs are used for recording. Crystal clocks are regulated by JJY standard waves or Loran C (Northwest Pacific Chain).

Due to the small sizes of telescopes, diffraction pattern of occultation can not be recorded, but times of double disappearance or reappearance are read with an accuracy of about 0.01 sec.

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3. Calculation

Since topocentric motion of the moon is obtained from the ephemeris, observed time difference between double event yields the location of the moon's limb passing a component, say A, of the double star with respect to the other component, say B. Namely, this portion of the moon's limb is a position line of A with respect to B. If same double event is observed at two stations, positional relation between A and B can be determined. However, if distance between the stations is small, two position lines make a small angle and a good accuracy of position fixing can not be expected. Three or more position lines are desirable generally. If occultations of same double star are observed at two epochs, intersection angle of position lines may be large. Assuming the period of the binary to be long, relative position of components can be obtained for a mean epoch.

TABLE 1 shows observation data and the results of calculations. Namely, 1st column: NZC No., 2nd column: ADS or BD No., 3rd column: disappearance or reappearance, 4th column: station code No. shown in Section 2, 5th column: observed time on UTC, 6th column: difference in time for double event, 7th column: inclination of the moon's limb to its mean circular disk (eastward positive) taken from the Watts' charts for two nearest neighbouring position angles, 8th column: position angle, 9th column: separation, and 10th column: epoch.

TABLE 1. OBSERVATION DATA AND RESULTS

NZC	ASD/BD	D/R	Stat.	Obs. UTC	Dur.	limb	P	d	Epoch
				d h m s	s	°	°	″	
438	2253	D	7	1970 Jan 16 9 36 43.64	1.23	−1.8			
		D	6	9 39 34.54	1.26	+1.1	258.4 ± .3	0.44 ±.00	1970.49
		D	6	Dec 10 10 58 39.04	1.61	−0.4			
		D	5	11 08 55.53	1.64	+6.0			
598	2965	D	7	1972 Dec 18 18 48 30.46	0.11	+0.4			
		D	6	1973 Feb 11 9 35 54.14	0.09	+3.7	213.8 ±2.4	0.095 ±.007	1973.06
		D	5	9 42 04.75	0.09	+3.8			
869	4324	D	7	1972 Feb 23 11 03 37.21	0.67	−1.3			
		D	6	11 10 59.55	0.80	−0.2	26.4 ±2.6	0.42 ±.04	1972.15
		D	5	11 13 00.03	0.42	+1.8			
996	+28°1138	D	*	1969 Mar 26 3 33 06.152	0.084	+0.9			
		D	7	Apr 22 11 51 48.55	0.07	+1.6	274.6 ±4.9	0.027 ±.002	1969.38
		D	6	11 55 01.51	0.07	+4.6			
		R	6	Sep 5 18 53 21.45	0.06	−2.2			
2872	12741	D	6	1971 Oct 26 11 09 44.43	0.18	−5.3			
		D	7	11 10 29.37	0.42	0.0	137.3 ±2.2	0.25 ±.03	1971.82
		D	5	11 11 35.67	0.20	+0.4			
3322	16130	D	7	1970 Dec 5 12 06 22.19	0.22	−0.7			
		D	6	12 09 26.83	0.47	−5.6	333.1 ±1.2	0.48 ±.03	1970.93
		D	5	12 11 50.22	0.33	−0.2			

* Observation at McDonald (Evans, 1971), observed time denoed as UT.

TABLE 2. O-C FOR ADS 2253

Epoch	Position angle	Separation	Source
	°	″	
1878.70	− 0.5	+ 0.09	Baize, 1958
85.18	− 4.7	+ 0.02	
90.92	+ 2.2	− 0.04	
97.68	+ 4.4	0.00	
1903.38	− 0.6	0.00	
12.48	− 1.2	− 0.01	
20.55	+ 1.8	+ 0.01	
26.24	+ 0.2	+ 0.01	
34.86	− 0.5	0.00	
38.46	+ 4.9	− 0.02	
44.68	+ 1.1	+ 0.01	
51.10	+ 1.1	− 0.02	
56.78	− 2.5	− 0.01	
58.08	+ 0.5	+ 0.04	
1963.778	− 3.9	− 0.01	Worley, 1967
1968.076	− 2.3	+ 0.04	Walker, 1969
1970.492	+ 0.1	+ 0.04	occultation

Due to the small sizes of telescopes, it is difficult to judge which component is primary or companion. In general, each position line was assumed to be of equal weight and probable errors of position angle and separation in columns 8 and 9 are those obtained by the least squares solutions. Then, errors in time and the limb inclination are not included in these probable errors. For BD +28°1138, a McDonald data by Evans (1971) was added with weight of 2, and the weights of two observations at the station 6 were taken as 0.5 due to their poor records. Figs. 1 to 6 show relative motions of the stars with respect to the moon, position lines and position fixings.

4. Discussion and Concluding Remarks

Among 6 binaries in TABLE 1, orbital elements are given merely for ADS 2253 in the Worley's catalog (1963). These elements were derived by Baize (1958) from data for 14 epochs from 1878 to 1958. TABLE 2 gives (O-C) for this binary. The first fourteen were given by Baize. The last three were obtained from observation data by Worley (1967), Walker (1969) and the present result of occultation, respectively. Magnitudes of (O-C) of the occultation method seem to be of ordinary sizes in comparison with those by the micrometer measurements.

Finsen (1971) informed that the position angle and separation of ADS 12741=53 Sgr might be not so far from 325° and 0″.18, though observation has discontinued since 1965. Agreement in position angle between his guess and the present result (137°.3+180°=317°.3) seems to be passable. According to him, maximum separation is about 0″.18 and hence the present result 0″.24 is

too large. As is seen in Fig. 5, the intersection angles of position lines are small and error in time causes a larger error in position fixing.

It is difficult to estimate the accuracy of double star measurement by occultation from merely above two examples. However, it is clear that the better result can be obtained from the larger intersection angle of position lines. Most results in TABLE 1 were derived from the position lines with small intersection angles, which may be attributed partly to the geometrical relation of three stations being situated nearly in east-to-west direction with distances 200 to 400 km. We should not overestimate these results even though the magnitudes of internal errors are small. In order to secure large angle of intersection, (i) observation stations should be situated enough far from each other, at least 1000 km, in north-to-south direction, or (ii) occultation observations for same star at different epochs are desirable. In truth, such observations could not be made intentionally because percentage of data acquisition for occultation observations is generally low. Data of double stars could be obtained merely as a by-product of routine observation of occultations.

However, present method of double star measurement does not require a large telescope comparing with the ordinary methods by micrometer and photograph. At present, not all the binary stars are included in the observation programmes of micrometer or photograph. Then, measurement by occultation would be of use to make up for the lack of ordinary observations.

References

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Worley, C. E. 1963, Ibid. *Second Ser.*, vol. XVIII, part III.

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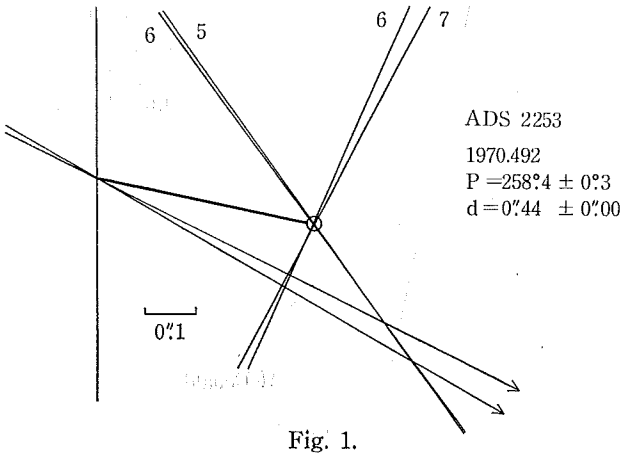


Fig. 1.

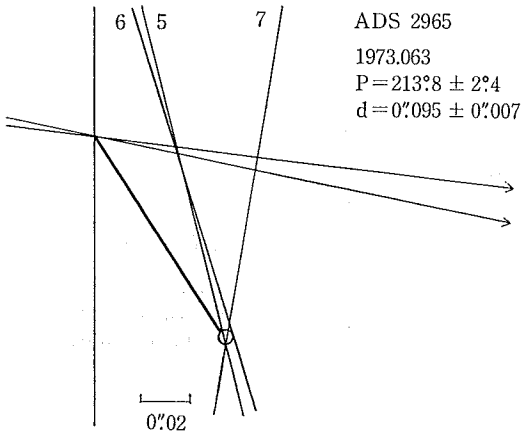


Fig. 2.

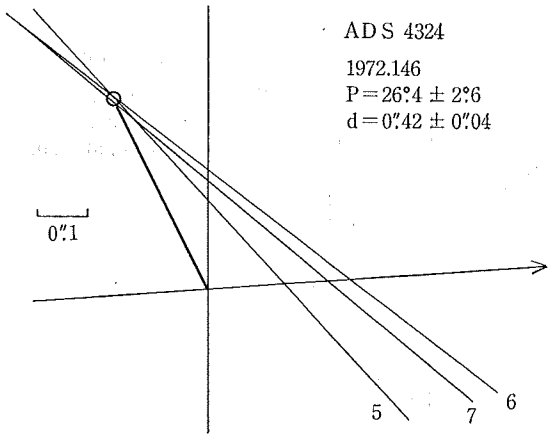
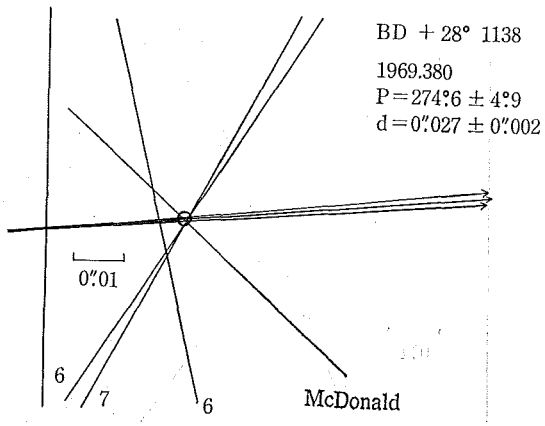


Fig. 3.



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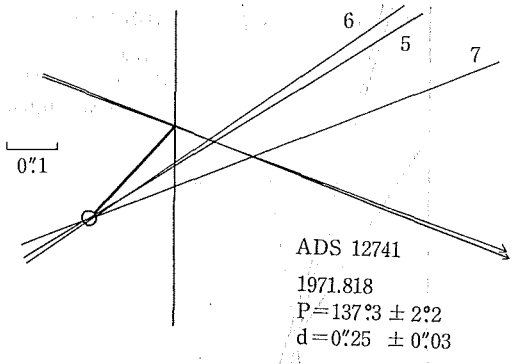

Fig. 5.

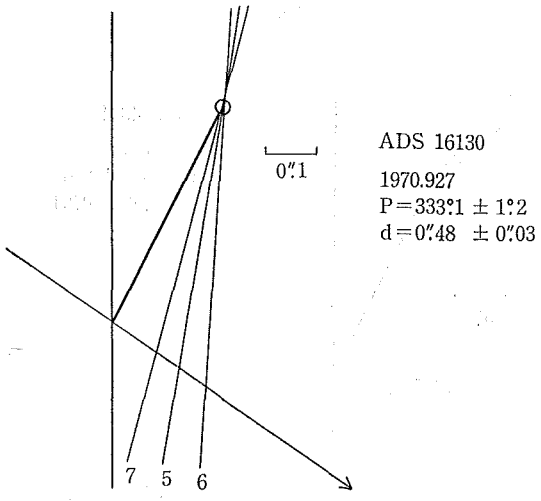

Fig. 6.