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PHOTOELECTRIC OBSERVATIONS OF LUNAR OCCULTATIONS. XVI

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ABSTRACT

A final list of 105 observations is presented including eight cases of certain or possible duplicity and two angular diameters. The results for 46 Leo (SAO 99172) are combined with previous values to yield a diameter, fully darkened, of 4.01 ± 0.85 milliarcsec. A detailed discussion of occultation and speckle results for σ Sco is given.

INTRODUCTION

Prime donne are notorious for the number of their farewell performances. The principal investigator in this series, which has been supported mainly by National Science Foundation grants since 1968, apologizes for the fact that Paper XV (Evans *et al.* 1985) did not clear up all the available observations and that we now present a final 105 results, in Table I, in the usual format, all observed at McDonald Observatory 30 in. reflector in two colors, usually blue clear (BC) and RG 610 filters. The letter following F in the notes column indicates which color was used for reduction. The columns DMS and DMB show the maximum magnitude differences which could have been detected against the star and background light, so that large numbers indicate low noise and high probability of companion detection if one existed. DS is the error associated with the limb slope when one was determined. Asterisks indicate notes to Table I and the designation R indicates a reappearance.

Table II shows results for duplicity ranked by designation: 3 for certain, 2 for probable, and 1 for possible detection. Table II contains some novel elements. In one case a double solution fits well but it is impossible to tell which component disappeared first, so the position angle is ambiguous by 180°. Two other cases depend on a remark by one of us (Andrew McWilliam) which may throw light on a variety of discrepant results which have turned up in the literature in which impossibly large values of angular diameters have been found. McWilliam suggests that these cases are in reality close binaries. The logic of the matter is that the occultation reduction process seeks to interpret a patch of light on the sky divided into strips parallel to the lunar limb and that it is possible to make the wrong interpretation of a close binary as a star with a sensible diameter. The entries noted in Table II have been tentatively reduced as doubles with the position angles ambiguous by 180°. Angular-diameter determinations are given in Table III.

SIGMA SCORPII DISCUSSED

The star is ADS 10009, for which we have σ Sco A: 2.88, $+0.14$, 0.70, B1 III, β Cep variable; σ Sco B: 8.44, $+0.35$, 0.15 and AB: 3.1, 8.7, 20″, 270° (1783); 20″.0, 273° (1959). Evidently B, the distant companion, is physically related.

Occultation observations in this paper and by Nather *et al.* (1974) show that σ Sco A is itself double. The observation of EB 234 (Eitters and Beavers 1977) in PA 288°.2 on 1 January 1973 did not show the secondary but the detection limits $\Delta m_* = 0.2$ and $\Delta m_0 = 1.9$ indicate that the secondary was probably lost in the noise. Our results show magnitude differences of 2.20 at 5214 Å and 2.41 at 6100 Å, while Nather *et al.* found 2.20 in the blue.

Adopting a magnitude difference of 2.20 we find for the primary of σ Sco A 3.03, $+0.14$, and $+0.70$ as the photometric parameters.

The star is evidently considerably reddened and from the standard $(U-B)$, $(B-V)$ plot we can estimate $\Delta(B-V) = 0.31$ or $(B-V)_0 = -0.17$ satisfactorily in agreement with the calibration of Allen (1973), who lists for β Cep stars of type B1 III, $(B-V)_0 = -0.2$, $M_{vo} - 4.5$, $\log M = 1.7$. From the above data we can take the value of V_0 for this star to be 2.01. The listed photometry for σ Sco B is less precise and puts the star in a region of the color-color plot where the determination of reddening is less precise. For it the reddening seems somewhat less, which is possible considering the Milky Way region in which the star lies.

The result from the primary gives a parallax of 0.005 arcsec. If the pair are in orbital motion with a mass of 60 $M_\odot$ and $a = 1$ arcsec the period is 365 yr. If $a = 0.5$ arcsec, $P = 129$ yr.

In spite of the vagueness of the foregoing parameter estimates, the conclusion is certain that if there is orbital motion its period is long, possibly of the order of one or several centuries.

On 1972.556, Nather *et al.* made two observations, both dark-limb disappearances with the secondary going first and found for two different observing stations with our observation added (the results of Table IV). The published position angles of Nather *et al.* have been increased by 180° in the light of the order of their events.

If the secondary is slow moving we may combine these using the equation $r \cos(\theta - \theta_n) = r_n$ to find the true position angle θ and separation r from the observed values θ_n and vector separations r_n. We find $r = 0.415$ arcsec, $\theta = 276°.4$ for a mean date 1977.12. The (O–C) residuals in r_n for the three observations are, respectively, $+8$, -7, and -1 milliarcsec.

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TABLE I. Occultation observations.

RUN	SAO/DM	MAG	SP.	U.T. DATE	UTC OBSERVED	DT	P.A.	W.A.	C.A.	DMS	DMB	SLOPE	DS	NOTES	EVENT
6759	77244	8.0	K0	01 MAR 85	3 45 21.702	1	100.1	102.0	-13.8	3.8	3.9	0.0	5.3	FR(BC,RG)	
6760	77271	8.5	K7	01 MAR 85	4 57 12.745	1	104.8	106.4	-14.1	3.6	3.6	-2.6	4.8	FR(BC,RG)	
6761	77278	9.1	A2	01 MAR 85	5 7 10.089	1	90.5	92.0	0.5	2.4	2.5			FB(BC,RG)	
6762	77281	7.8	A0	01 MAR 85	5 15 35.804	0	117.5	-26.2	119.0	3.8	4.0			FB(BC,RG)	
6763	77289	8.8	K5	01 MAR 85	5 22 58.524	1	107.1	108.8	-15.6	2.4	2.5			FR(BC,RG)	
6764	77298	9.0	A7	01 MAR 85	5 36 21.120	1	73.8	75.1	18.2	2.5	2.6			FB(BC,RG)	
6765	77310	6.3	F5	01 MAR 85	5 51 38.802	0	90.0	91.4	2.5	4.3	4.4	-24.8	2.5	FB(BC,RG)*	
6766	77301	9.1	A	01 MAR 85	5 56 57.633	2	28.0	29.3	64.5	2.8	2.9			FB(BC,RG)	
6767	77316	9.3	A	01 MAR 85	6 3 2.916	1	73.9	75.3	18.8	2.6	2.7			FB(BC,RG)	
6768	+25 0886	10.3	B8	01 MAR 85	6 29 57.077	4	54.7	56.0	38.7	1.4	1.5			FB(BC,RG)	
6769	77335	9.1	K5	01 MAR 85	6 33 45.047	3	116.6	118.0	-23.2	1.4	1.5			FR(BC,RG)	
6770	77337	9.0	G0	01 MAR 85	6 36 18.097	2	69.8	71.0	23.7	2.2	2.6			FB(BC,RG)*	
6771	77360	5.0	B3	01 MAR 85	7 26 56.614	1	90.0	91.0	3.9	2.9	3.0			FB(BC,RG)*	
6772	78361	8.8	K7	02 MAR 85	1 5 42.774	2	20.1	16.7	61.5	2.8	2.9			FR(BC,RG)	
6773	78381	9.1	A7	02 MAR 85	1 17 28.312	1	82.5	79.1	0.1	2.5	2.8			FB(BC,RG)	
6774	78385	9.1	F8	02 MAR 85	1 25 18.733	2	116.1	112.6	-33.0	2.4	2.5			FB(BC,RG)	
6775		11.2	F0	02 MAR 85	1 44 1.314	4	63.4	59.9	20.8	1.5	1.6			FB(BC,RG)*	
6776	+27 1119	11.0	K0	02 MAR 85	2 13 46.434	4	63.7	60.0	22.7	1.6	1.7			FR(BC,RG)	
6777	78417	6.5	F5	02 MAR 85	2 33 42.410	1	54.7	51.0	33.2	4.3	4.4	6.8	2.0	FR(BC,RG)*	
6778	78422	8.8	G5	02 MAR 85	2 46 33.124	2	42.7	39.0	46.0	2.5	2.6			FB(BC,RG)	
6779	78578	8.8	A0	02 MAR 85	8 0 15.364	1	97.9	93.4	3.0	2.2	2.3			FB(BC,RG)	
6780	80857	8.6	G5	05 MAR 85	2 36 11.230	3	96.0	77.8	12.0	1.7	1.8			FR(BC,RG)	
6781	80876	9.0	K0	05 MAR 85	3 33 36.979	3	91.9	73.5	19.7	1.8	1.9			FR(BC,RG)	
6782	80886	7.4	K0	05 MAR 85	3 56 8.704	1	82.6	64.3	30.5	3.6	3.7	5.1	3.1	FR(BC,RG)	
6783	80888	9.1	G0	05 MAR 85	4 0 51.452	4	82.3	63.9	31.2	1.3	1.4			FB(BC,RG)	
6784	80890	8.3	F5	05 MAR 85	4 11 8.441	1	64.9	46.5	49.2	3.2	3.3			FB(BC,RG)	
6785	80898	7.6	K0	05 MAR 85	4 32 19.842	1	93.1	74.8	22.2	3.0	3.1	-1.8	5.9	FR(BC,RG)	
6786	98668	8.6	G5	05 MAR 85	7 47 41.128	5	181.6	163.0	-60.0	1.9	2.3			FR(BC,RG)*	
6787	+19 2239	9.6	G0	05 MAR 85	8 57 8.934	1	140.8	122.1	-20.1	2.7	2.8			FB(BC,RG)	
6788	98705	9.3		05 MAR 85	9 58 26.331	3	161.6	142.8	-42.5	1.4	1.5			FB(BC,RG)	
6789	99144	7.5	K0	06 MAR 85	3 14 22.660	1	121.3	100.3	-6.4	2.7	2.9			FR(BC,RG)*	
6790	99159	9.0	K0	06 MAR 85	3 58 16.063	6	104.7	83.6	12.8	1.1	1.2			FB(BC,RG)	
6791	99172	5.6	M0	06 MAR 85	5 48 17.324	0	140.0	118.9	-16.2	4.2	4.3	1.5	8.2	FB(BC,RG)*	
6792	79142	6.8	K0	30 MAR 85	5 50 5.608	1	112.1	104.5	-6.5	2.9	3.0			FR(BC,RG)*	
6793	79921	8.8	K0	31 MAR 85	2 48 8.503	3	125.3	113.0	-17.7	1.8	1.9			FB(BC,RG)	
6794	79943	9.0	F0	31 MAR 85	3 44 35.390	2	118.9	106.5	-8.3	2.1	2.2			FB(BC,RG)	
6795	79957	9.1	K7	31 MAR 85	4 46 38.731	1	149.8	137.5	-37.5	2.7	2.8			FR(BC,RG)	
6796	79965	9.1	K0	31 MAR 85	4 59 13.426	1	146.1	133.6	-33.5	2.6	2.7			FB(BC,RG)	
6797	79980	8.0	G5	31 MAR 85	5 27 22.738	1	97.1	84.6	15.6	3.5	3.6	-3.3	4.8	FR(BC,RG)	
6798	79981	9.1	A2	31 MAR 85	5 44 52.912	2	145.8	133.3	-33.0	2.3	2.4			FB(BC,RG)	
6799	79996	9.1	G0	31 MAR 85	6 6 12.243	2	98.1	85.5	14.6	2.1	2.2			FB(BC,RG)	
6800	+25 1867	11.3	K0	31 MAR 85	6 10 17.212	2	103.4	90.6	9.3	1.8	1.9			FR(BC,RG)	
6801	80011	9.1	K0	31 MAR 85	7 3 57.787	2	113.1	100.4	-1.2	1.8	1.9			FR(BC,RG)	
6802	80597	8.1	G5	01 APR 85	2 8 46.799	1	79.0	62.4	32.0	3.4	3.6	-5.0	2.5	FR(BC,RG)	
6803	+22 2038	11.2	G5	01 APR 85	2 17 37.309	4	144.0	127.5	-32.4	1.4	1.6			FB(BC,RG)	
6804	80622	9.1	K5	01 APR 85	4 32 9.167	5	161.5	144.8	-43.2	1.2	1.4			FB(BC,RG)*	
6805	80645	8.8	G5	01 APR 85	5 18 14.858	1	99.0	82.1	20.2	2.3	2.5			FR(BC,RG)	
6806	+21 1976	11.1	G5	01 APR 85	5 54 17.047	4	120.1	103.3	-0.8	1.1	1.2			FB(BC,RG)	
6807	80658	9.0	F5	01 APR 85	6 3 44.263	1	117.8	100.9	1.5	2.9	3.1			FB(BC,RG)	
6808	80672	9.1	A5	01 APR 85	7 17 54.297	1	158.6	141.6	-40.5	2.3	2.5			FB(BC,RG)*	
6809	80698	9.6	K0	01 APR 85	8 30 46.823	2	96.0	78.9	20.1	1.6	1.7			FR(BC,RG)	
6810	+21 1994	9.6	G5	01 APR 85	8 55 38.517	3	119.0	101.9	-3.7	1.4	1.5			FR(BC,RG)	
6811	98894	7.9	F5	02 APR 85	2 24 36.084	1	108.6	88.9	8.1	2.6	2.7			FR(BC,RG)	
6812	+18 2305	10.5	G5	02 APR 85	2 42 39.610	6	137.0	117.1	-19.0	0.8	0.9			FB(BC,RG)	
6813	98898	9.1		02 APR 85	2 50 25.545	2	83.6	63.7	34.7	2.4	2.5			FB(BC,RG)	
6814	+18 2307	9.6	G5	02 APR 85	3 5 44.094	5	115.0	95.1	4.3	1.1	1.2			FR(BC,RG)	
6815	98955	3.5	A0P	02 APR 85	6 58 41.911	1	61.0	40.7	63.0	4.5	4.6	4.5	0.5	FB(BC,RG)*	
6816	98971	9.3		02 APR 85	8 13 27.318	4	126.0	105.9	-4.0	1.0	1.1			FB(BC,RG)*	
6817	98974	8.6	G5	02 APR 85	8 37 37.561	1	155.0	134.8	-33.9	2.9	3.0			FB(BC,RG)*	
6818	98983	8.3	K2	02 APR 85	8 48 27.015	1	109.8	89.5	11.0	2.3	2.5			FR(BC,RG)*	
6819	98984	7.8	F0	02 APR 85	9 21 7.784	1	178.6	158.3	-59.2	3.5	3.7			FB(BC,RG)	
6820	99366	8.8		03 APR 85	2 26 41.873	2	91.1	69.4	29.0	2.2	2.3			FB(BC,RG)	
6821	99389	8.5	F8	03 APR 85	4 14 16.064	1	68.0	46.1	58.0	3.0	3.1			FB(BC,RG)	
6822	99437	8.6		03 APR 85	8 47 4.349	5	83.3	61.2	41.5	1.2	1.3			FR(BC,RG)	
6823	99443	8.3	F8	03 APR 85	9 11 30.040	1	135.0	113.0	-11.1	2.1	2.2			FB(BC,RG)	
6824	99455	7.3	F8	03 APR 85	9 23 51.497	1	64.5	58.7	58.7	3.1	3.3			FR(BC,RG)*	
6825	99456	9.0	F8	03 APR 85	9 29 57.704	3	61.2	39.2	61.7	1.9	2.1			FB(BC,RG)	
6827	119156	5.1	A0	04 APR 85	8 10 44.052	0	122.5	100.0	6.1	3.7	3.9	-2.8	3.1	FB(52,RG)*	
6828	119169	7.9	F5	04 APR 85	8 51 53.515	1	83.9	61.5	43.2	2.9	3.1			FB(BC,RG)	
6830	139377	8.1	K5	27 JUN 85	4 3 23.158	1	66.9	46.9	59.4	3.8	3.9	-1.9	0.9	FR(BC,RG)	

TABLE I. (continued)

RUN	SAO/DM	MAG	SP.	U.T. DATE	UTC OBSERVED	DT	P.A.	W.A.	C.A.	DMS	DMB	SLOPE	DS	NOTES	EVENT
6831	139383	8.6	G5	27 JUN 85	4 25 24.372	2	78.3	58.2	46.7	2.6	2.7			FB(BC,RG)	
6832	139405	7.1	G0	27 JUN 85	5 34 49.955	0	111.0	91.0	10.0	3.5	3.7			FB(BC,RG)	
6833	139408	7.6	G5	27 JUN 85	5 42 54.258	1	102.1	82.3	18.2	3.0	3.1			FB(BC,RG)	
6834	139415	7.4	F8	27 JUN 85	6 15 11.050	1	114.4	94.5	4.1	2.9	3.1			FB(BC,RG)*	
6835	158546	7.4	G5	28 JUN 85	4 3 32.147	1	70.4	53.2	53.7	3.9	4.0			FB(BC,RG)	
6836	159175	7.6	F5	29 JUN 85	2 58 25.605	0	113.4	100.1	9.1	3.8	3.9			FB(BC,RG)	
6837	159213	8.6	K0	29 JUN 85	5 13 5.375	1	67.0	54.0	49.2	2.9	3.1			FR(BC,RG)	
6838	159237	8.1	K2	29 JUN 85	6 0 25.126	1	76.0	63.0	37.0	3.1	3.2			FR(BC,RG)	
6839	184322	9.3	F8	30 JUN 85	2 55 50.057	11	84.1	76.0	32.5	0.6	0.7			FB(BC,RG)	
6840	184329	4.8	A3	30 JUN 85	3 31 1.980	1	145.8	137.8	-30.0	3.4	3.5	-3.3	1.3	FB(SV,SY)*	
6841	184345	9.0	A0	30 JUN 85	4 36 35.769	7	149.8	141.8	-36.7	0.9	1.0			FB(BC,RG)	
6842	184347	8.6	A0	30 JUN 85	4 45 56.064	1	148.1	140.1	-35.5	2.6	2.7			FB(BC,RG)	
6843	184958	9.1	A3	28 JUL 85	3 51 41.109	2	121.4	117.0	-16.6	2.0	2.1			FB(BC,RG)	
6844	184993	8.5	K2	28 JUL 85	4 34 53.827	1	71.3	67.0	30.3	3.0	3.1			FR(BC,RG)	
6845	185001	8.8	B9	28 JUL 85	4 59 19.683	2	134.8	130.6	-34.9	2.3	2.4			FB(BC,RG)	
6846	-26 11875	8.8	K5	28 JUL 85	5 11 30.080	2	83.0	79.0	15.8	2.3	2.4			FR(BC,RG)	
6847	185020	7.5	F5V	28 JUL 85	5 34 59.772	0	127.1	123.1	-29.8	3.7	3.8	5.4	5.2	FR(BC,RG)*	
6848	185033	6.1	A0	28 JUL 85	5 55 41.724	0	107.1	103.1	-11.1	4.7	4.8	-9.8	1.3	FB(B ,RG)*	
6849	-26 11875	9.3	KP	28 JUL 85	6 26 9.749	3	59.7	55.9	34.5	1.8	1.9			FR(BC,RG)	
6850	185077	8.8	K5	28 JUL 85	7 5 47.925	1	80.5	76.6	11.8	2.7	2.8			FR(BC,RG)	
6851	186349	7.4	K0	29 JUL 85	5 16 30.068	1	56.7	58.5	34.7	3.1	3.2			FB(BC,RG)	
6852	186351	8.6	K0	29 JUL 85	5 25 23.758	3	44.2	46.2	46.4	2.1	2.3			FR(BC,RG)	
6853	186361	7.5	K5	29 JUL 85	5 36 47.891	1	42.5	44.5	47.2	4.0	4.1	2.5	1.5	FR(BC,RG)	
6854	187723	9.0	F0	30 JUL 85	3 2 48.062	5	91.3	98.8	1.6	1.1	1.2			FB(BC,RG)	
6855	187826	9.3	G0	30 JUL 85	5 33 51.500	7	97.8	105.6	-15.1	1.0	1.1			FB(BC,RG)	
6856	187869	8.8	K0	30 JUL 85	6 46 21.302	8	74.5	82.5	3.2	0.9	1.0			FR(BC,RG)	
6857	187861	8.5	A0	30 JUL 85	6 49 42.842	3	36.2	44.4	41.2	2.6	2.8			FB(BC,RG)*	
6858	-26 14840	8.5	A2	31 JUL 85	3 54 43.835	9	50.2	63.2	32.4	0.3	0.5			FB(BC,RG)	
6858B	185755	4.4	F8	25 AUG 85	2 54 15.398	1	96.3	96.0	-0.2	3.9	4.0			FR(BC,RG)*	
6859	188613	7.4	K0	27 AUG 85	2 31 12.613	1	73.6	84.9	9.6	3.2	3.3			FR(BC,RG)	
6860	188722	4.8	G5	27 AUG 85	6 11 51.152	0	52.2	63.9	16.7	4.6	4.7			FR(BC,RG)*	
6861	188778	5.0	G5	27 AUG 85	7 52 59.088	0	89.0	101.0	-21.7	4.4	4.5			FR(BC,RG)*	
6862	164601	6.1	A3	29 AUG 85	3 27 23.439	1	26.5	45.7	41.5	4.1	4.2	-6.7	1.5	FB(BC,RG)*	
6863	164697	6.0	F2	29 AUG 85	9 22 38.008	0	70.9	90.4	-14.8	4.0	4.1			FB(BC,RG)*	
6864	184336	3.1	B1	30 MAR 86	9 45 23.810	0	265.5	267.4	-150.7	3.5	4.1	-6.1	1.0	FB(52,RG)*	R

Notes to TABLE I. Italicized numbers are those of other runs on the same star.

Run No.	Star	
6765	77310	HR 1889, HD 36994, +25°879. 6.49, +0.43, F5 III.
6770	77337	+25°888. Double, see Table II.
6711	77360	125 Tau, HR 1928, HD 37438, +25°902. 5.18, −0.15, −0.68, B3 IV. SB 27.864 d. Bright Star Catalogue states occultation triple. Not detected on this run.
6775		USNO No. X09095.
6777	78417	*Hamburg* (de Vegt 1976) HR 2339, HD 45504, +27° 1122. 6.47 F5. Double, see Table II.
6786	98668	+19°2232. Double, see Table II.
6789	99144	*6602.*
6791	99172	*Poss* (1971), *6604, Schmidtke et al.* 46 Leo, HR 4127, HD 91232, +14°2255, 5.46, +1.68, M 1.5 IIIbCa-I. Diameter, see Table III.
6792	79142	*1313.*
6808	80672	*Rakos 55* (1971).
6815	98955	*6612,* η Leo, HR 3975, HD 88737, +17°2171, 3.52, −0.03, −0.21 AoIb, ? var ?. Double, see Table II.
6816	98971	*6615.*
6817	98974	*6617.*
6818	98983	*6616.*
6821	99389	*6619.*
6824	99455	*6621.*
6827	119156	7 Vir, HR 4585, HD 104181, +4°2556, 5.37, −0.00, +0.00, A1 V.
6834	139415	−7°3643. Double, see Table II.
6840	184329	*o* Sco, HR 6081, HD 147084, −23°12849, 4.55, +0.84, +0.62, A5 II. ? var ?.
6847	185020	BF Oph, −26°11880. Cepheid 4.06775 d.
6848	185033	HR 6354, HD 154481, −26°11896. 6.29, −0.04, −0.24, AO III. RV var.
6857	187861	−27°13715. Double, see Table II.
6858B	185755	3 Sgr, X Sgr, HR 6616, HD 161592, 4.54, +0.80, +0.50, F7 II. Cepheid 7.01225 d.
6860	188722	ω Sgr, HR 7597, HD 188376, −26°14637. 4.70, +0.75, +0.32, G5 V. SB. Double, see Table II.
6861	188778	60 Sgr, HR 7618, HD 189005, −26°14682. 4.83, +0.90, +0.55, G6 III Ba 0.2. Diameter, see Table III.
6862	164601	HR 8293, HD 206546, −20°6270. 6.22, +0.27, +0.15 A3 m. SB 6.3702 d. Double, see Table II.
6863	164697	*6699.* HR 8346, HD 207760, −19°6176. 6.16, +0.36, F0 III.
6864	184336	*Nather (1974) EB 234.* σ Sco HR 6084, HD 147165, −25°11485 ADS 10009 Double, see Table II and detailed discussion.

TABLE II. Double star observations.

SAO	Run No.	UT Date	mag	Sp	Vector separation (arc seconds)	P.A. (deg.)	Δm		Rank	Slope (deg.)
077337	6770	01 Mar 85	9.0	G0	0.0271 ± 0.0016	249.8	0.43 ± 0.36	(BC)	3	
					0.0261 ± 0.0033		0.89 ± 0.69	(RG610)	3	
078417	6777	02 Mar 85	6.5	F5	0.0040 ± 0.0005	61.5[a]	3.40 ± 1.00	(BC)	2	6.8 ± 2.0
					0.0036 ± 0.0015	58.0[a]	2.40 ± 0.60	(RG610)	2	3.3 ± 2.0
098668	6786	05 Mar 85	8.6	G5	0.0332 ± 0.0016	181.7	0.82 ± 0.40	(BC)	3	
139415	6834	27 Jun 85	7.4	F8	0.7260 ± 0.0050	114.4	0.09 ± 0.19	(BC)	3	
					0.7252 ± 0.0050	294.4	0.15 ± 0.16	(RG610)	3	
187861	6857	30 Jul 85	8.5	A0	0.0968 ± 0.0015	36.3	0.10 ± 0.26	(BC)	3	
188722	6860	27 Aug 85	4.8	G5	0.0017 ± 0.0005	51.3[b]		(BC)	1	− 0.9 ± 2.5
					⩽ 0.0010 ± 0.0005	44.9[b]		(RG610)	1	− 7.3 ± 1.5
164601	6862	29 Aug 85	6.1	A3	0.0009 ± 0.0005	17.9[b]		(BC)	1	− 8.6 ± 1.5
					0.0011 ± 0.0005	21.6[b]		(RG610)	1	− 4.9 ± 1.5
184336	6864	30 Mar 86	3.1	B1	0.3946 ± 0.0050	259.4	2.20 ± 0.07	(G5214)	3	− 6.1 ± 1.0
					0.3946 ± 0.0050		2.41 ± 0.16	(RG610)	3	

[a] P.A. ambiguous to 180°.
[b] Diameter solutions run.

Notes to TABLE II

Star	Run No.	
077337	6770	New double star.
078417	6777	Hamburg, de Vegt [Astron. Astrophys. **48**, 245 (1976)] has double, separation 3 mas, P.A. 269° but magnitude difference 0.9 ± 0.7.
098668	6786	New double star.
139415	6834	ADS 8950 7.9, 8.4, 0″.3 127° (1960) appears to have closed since 1960.
187861	6857	New double star.
164601	6862	Hyades group. Bright star catalogue has separation 0.001″, luminosity III.
184336	6864	σ Sco, see detailed discussion.

This establishes that the secondary was west of the primary during recent years.

We are indebted to Dr. H. McAlister for making available a list of recent speckle interferometry observations in advance of publication. The standard convention is to state position angles between zero and 180° and our remarks above show that his published values must be increased by 180°. These modifications have been made in Table V. In our discussion we average the groups in 1980 and 1981. We also note that the mean occultation position is not in bad agreement with these results.

TABLE III. Angular diameter determinations.

Star	Run No.	UT Date	Mag	Sp.	Angular Diameter (*fd*) (milliarcsec)
99172	6791	06 Mar 85	5.6	M0	3.9 ± 1.1 (BC)
					4.7 ± 1.0 (6100)
188778	6861	27 Aug 85	5.0	G5	⩽1.2 + 0.5 (BC)
					⩾1.2 ± 0.5 (6100)

Notes to TABLE III

SAO 099172, 46 Leo: Run No. 6604 (noisy): No result.

Other results:

Poss: 5.6 ± 1.1 mas (uniform disk) 26.05.66

Schmidtke *et al.*:

3.04 ± 0.76 (0.96 μ) (uniform disk)
3.11 ± 0.24 (1.65 μ) 19.05.83
3.70 ± 0.32 (2.22 μ)

4.45 ± 0.62 (0.45 μ) (uniform disk)
3.75 ± 0.20 (0.58 μ) 12.04.84
2.93 ± 0.65 (0.96 μ)
3.28 ± 0.28 (1.65 μ)
2.17 ± 0.7 (2.17 μ)

This paper 3.9 ± 1.1 (BC)
4.7 ± 1.0 (6100) Fully darkened 06.03.85

Adjusting the uniform disk results by 13% to give fully darkened values, the straight mean for full darkening to the limb is 4.01 ± 0.85 mas.

Using the McAlister group observations we find that r^{-2} varies exactly linearly over the range from 1977 to 1984. Using units of (seconds of arc)^2 and rate of change of θ (degrees per year) we estimate the areal constant $r^2\dot{\theta} = 0.2610$ with $\dot{\theta} = 2.09$ in 1977 and 1.77 in 1984.

We can estimate the true values of r and θ in 1986 by the following iterative procedure. Extrapolate $\dot{\theta}$ to give an average value from 1984 to 1986 to estimate θ. Then require the secondary to be on the 1986 occultation position line and deduce r, from which a better value of $\dot{\theta}$ can be inferred. The result for 1986.243 is $r = 0.392$ arcsec, $\theta = 268^\circ.5$.

Nather *et al.* combined their two observations to deduce $r = 0.49$ arcsec in P.A. 268° at 1972.556. However, this result depends on the concurrence of two position lines inclined to each other at only 9°, admittedly open to criticism. We shall extract better information from their two observations by assuming that they are subject to error and seeking a position for the secondary which best fits them using the iterative procedure. We arrive at $r = 0.322$ arcsec, $\theta = 296^\circ.8$. The residuals in r are + 20 and − 20 milliarcsec.

There are a number of old visual observations, details of which have kindly been supplied by Mr. J. Churms of the South African Astronomical Observatory.

The most circumstantial of these is by Dawson at La Plata (1931) on 1931.564, who saw a disappearance, primary first ("More than half the light went first") at a calculated vector separation of 0.114 arcsec in P.A. 63°.9. Even for a highly skilled visual observer, the estimate of a time interval of about half a second must be accepted with a degree of cau-

TABLE IV. Photoelectric occultation observations.

Place	P.A.	Vector separation (arcsec)
Sutherland	317°.4	0.321
Capetown	326°.1	0.261
McDonald	259°.4	0.395

TABLE V. Speckle observations.

Date	P.A. (deg)	r (arcsec)	References
1976.471	291.8	0.326	Morgan *et al.* (1978)
77.487	285.4	0.353	McAlister *et al.* (1979)
80.479	277.4	0.367	McAlister *et al.* (1983)
80.482	277.9	0.367	McAlister *et al.* (1983)
81.457	275.2	0.372	McAlister *et al.* (1984)
81.470	277.1	0.369	McAlister *et al.* (1984)
81.473	275.6	0.369	McAlister *et al.* (1984)
83.425	272.9	0.378	McAlister *et al.* (unpub.)
84.378	272.3	0.384	McAlister *et al.* (unpub.)

tion, and the position line based on these data could be shifted in either direction parallel to itself. However, as it happens the particular direction of this position line (see Fig. 1) enables us to get a good estimate of the 1931 position. Assume that the position lies on the northern part of the line. The alternative would involve the orbit having swept round from the southern part and back across the northern part to reach the 1968 position in time and numerically $\dot{\theta}$ would have to be very large. Later discussion will suggest that this is not so. So θ must be between 64° and 334° and r between 0.114 arcsec and infinity. If we guess at a series of values for θ, r must vary greatly and $\dot{\theta}$ vary wildly. By trial and error we arrive at a position such that the secondary could have gone from the position line to the speckle assemblage in the time available. The result, necessarily somewhat approximate, is $r = 0.4$ arcsec, $\theta = 350°$.

Mr. Churms has analyzed a reappearance on 1860.195 at position angle 314° with an estimated vector separation of 0.23 arcsec, the components appearing in the order SP. This leads to suggested values near 0".45 in P.A. 20° naturally with considerable uncertainty.

A reappearance was observed (i.e., "glided") at the Cape on 1968.293 in position angle 244°. Nather *et al.* say "bright limb reappearance," but as the date was April 16 and the full moon was on April 13 this cannot be so.

An approximate position line has been drawn using the Nather *et al.* offset of 0.08 arcsec but this could easily be much larger, as any experienced visual observer of occultations will know, being based on an interval estimated as one fifth of a second of time.

There was a bright limb reappearance later in the year at P.A. 285° but Churms' report does not refer to this event.

A close disappearance was observed at the Union Observatory, Johannesburg, on 1953.630 at P.A. 55° described as "slow." Again an approximate position line has been drawn. This gets all the events in the right order.

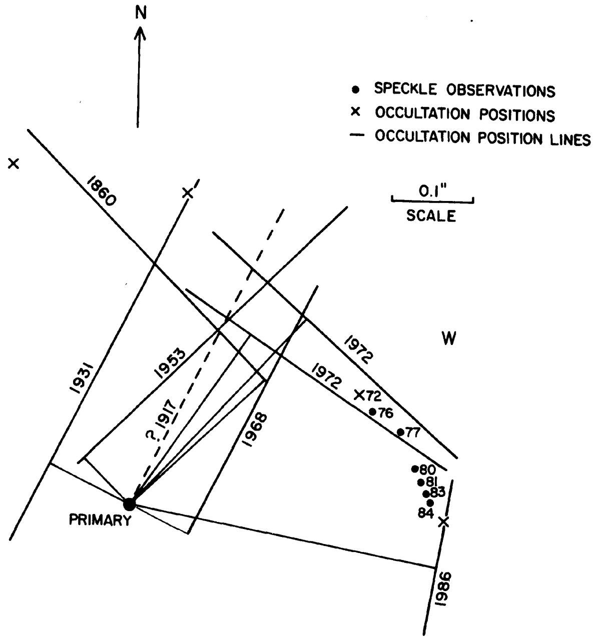

FIG. 1. Positions of the secondary of Sigma Scorpii.

One problem remains. On 1917.274 a dark-limb reappearance was observed at the U.S. Naval Observatory in P.A. 244° and described as "gradual." We have drawn a position line through the primary in the appropriate direction since we cannot estimate either the amount or direction, east or west, of the vector separation. As it stands, this is inconsistent but it would not take much in the way of alteration of the visual data to get this line to the east of the 1931 one.

The general result gives what seems to be a plausible section of the visual orbit from 1860 to the present time (Fig. 1). We will not push matters further at this time, bearing in mind the sage words of the late W. H. van den Bos, who counseled against the deduction of orbits from limited arcs.

It is a pleasure to express our thanks to Dr. H. McAlister and to Mr. J. Churms for information on Sigma Scorpii. This research has been supported by NSF grant No. AST 8309499 and by The University of Texas Research Institute. We are also indebted to Dr. David Dunham and Mrs. M. Lukac for independent computer verification of the occultation circumstances of Sigma Scorpii used in our discussion.

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