Lunar Occultation Observations of Double Stars – Report #6

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Abstract: Reports are presented of lunar occultations of close double stars observed using video techniques. Included are cases where a determination of the position angle and separation of the pair can be made as well as instances where no duplicity has been observed of known or reported double stars. A number of double stars discovered as a result of an occultation are also included together with the light curves for the discovery event.

This paper continues the series of reports of double star measurements made at lunar occultations of the star. The majority of the observations date from 2015 and 2016 although there are a few considerably earlier.

The principle and general method of calculation are explained in Herald (2009) and Loader (2010).

With one exception, all occultations presented in this paper have been observed using video cameras, mostly at either 25 frames, 50 fields per second (Australasia and Europe) or 30 frames, 60 fields per second (USA and Japan). A video time inserter has been used to time-stamp each video field to millisecond precision. The limit of timing accuracy is usually about ±0.02 seconds where analysis has been carried out using video frame measures and ±0.01 seconds using field measures. An error of 0.01 seconds in time will typically translate to an angular error of 4 arc milliseconds.

Video records of double star occultations have been analyzed using the Limovie program developed by K. Miyashita. This program measures the light flux of the occulted star from the video record and so allows a light curve for the event to be generated.

Occultations of double stars result in a stepped light curve, see Herald (2009). The duration of the step gives a measure of the separation of the pair in a direction perpendicular to the moon's limb at the point of occultation. The relative heights of the steps allow an estimate of the magnitude difference of the two stars to be made. Limovie has a facility to do this and to add the results to the light curve. Observations are normally made with an unfiltered CCD video camera.

Normally the separate occultations of the two stars of a pair will take place at slightly different points on the moon's limb. An angular separation of 1" at the mean distance of the moon is equivalent to about 1.86 km. The heights of the moon's limb at the two points of occultation may differ. Any difference will have an effect on the interval between the two events.

For each observation an estimate of the effective slope of the moon's limb between the two points of occultation is therefore needed for calculations of the position angle and separation angle of a pair of stars. For this paper use has been made of the new limb data from the Lunar Reconnaissance Orbiter, Lunar Orbiter Laser Altimeter.

The Observations Reported

Table 1 continues the series of measures of known double stars for which a solution for the position angle and separation of the system has been calculated. In order to produce a solution at least two observations are needed for which the occultations are well separated on the moon's limb. A minimum separation of 10° round the moon's limb is needed to obtain a reliable result.

Ideally the observations would all be made on the same date but this is rarely possible. In most cases the occultation observations have been made on different dates, with an interval between them sufficiently short for any change in relative position of the pair of stars to be small. Besselian dates of each observation and the mean date of the combined observations are shown. An estimate of any change in the expected position angle and separation of the pair, as indicated by the Washington Double Star (WDS) data, is given in the notes. The changes shown cover the period in which the observations were made.

The observed magnitude differences, as calculated by Limovie, are also shown.

Table 2 shows a number of occultation observations of double stars listed in the WDS for which only one observation is available. For most of them no further occultations will occur before the end of 2022.

With only one observation the actual position angle and separation of the pair of stars cannot be determined. Only a vector separation in the direction of the position angle of the moon's limb at the point of observation can be found.

An apparent magnitude difference can also be determined. The cataloged difference and the observed are shown, the latter with an estimate of the error. In the case of LSC 4 no magnitude for the secondary star has been published previously. The resulting magnitudes of the pairs are also listed, based on the published combined magnitude.

Tables 3A and 3B present details of previously unknown double stars discovered as a result of stepped lunar occultations.

Table 3A shows cases where more than one occultation of the new double has been made enabling the position angle and separation of the pair to be established. Similar data to Table 1 is presented.

Table 3B shows the far more numerous cases where only one observation has been made of the new double, resulting in the determination of a vector separation of the pair. In some cases two observations were made, but the separation of the occultation events on the moon's limb was too small to generate a reliable solution.

Only cases where the resulting light curve shows a reasonably well defined step have been included. Discovery light curves are presented for the events. The captions for the curves give some further details.

Table 4 presents observations of stars which have been reported as possibly double as a result of earlier visual occultation observations. More recent video observations of occultations for the stars listed have shown no sign of a stepped event, that is, no indication that it is double. Only cases with two or more observations with event position angles (the vector angle) separated by at least 10° have been included. The stars in Table 4 all have an entry in the Interferometric Catalog, most also have entries in the WDS.

While the most likely reason for the failure to detect a companion star is simply that the star is in fact single, other possible reasons are:

- The vector separation was so small that the interval between the two events was too short to detect. This possibility is largely eliminated by having two or more observations of the star at different position angles round the moon.

- The magnitude difference of the two component stars is too large for the fainter star to be detected at the occultation.

Table 5 contains similar data to Table 4 for stars with entries in the Washington Double Star Catalog but which have failed to show any double star nature during lunar occultations of the star. Those listed in the table had predicted intervals between the two occultations and component magnitudes making it likely any occultation would have separated the pair.

The names of all contributing observers are listed at the head of this paper and are referred to by the two letter code in the tables.

XZ refers to the XZ80Q catalog, available at VizieR as catalog I/291. It includes all stars to magnitude 12.5 within 6°40’ of the ecliptic, that is, all stars which can be occulted by the moon.

OCC# is the number assigned to the possible double at the discovery.

Acknowledgements

This research has made use of the Washington Double Star Catalog (WDS) and the Interferometric Catalog, both maintained by the United States Naval Observatory, Washington.

References

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Loader B., 2014, “A Possible New Double Star from Lunar Occultation: SAO 163677”, *JDSO*, **10** (1), 2-3.

Gault D., 2014, “A New Double Star Observed During Lunar Occultation, HIP 18473”, *JDSO*, **10** (1), 4-5.

The program “Limovie” by K. Miyashita can be downloaded from: http://astro-limovie.info/limovie/limovie_en.html

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Table 1. Known double stars: PA and separation measured

WDS Name	XZ	Position RA Dec	Measured PA° & Sep"	Mean Date	Mag. Diff.	Observn. Date	Observers	Note
MCA 7	3503	02366+1227	PA 328.15±0.21° Sep 0.089±0.001"	2015.70	0.57±0.15 n/a	2015.597 2015.897	DG,DH BL	1
COU 560AaAb	4845	03456+2420	174.16 ± 0.36° 0.096 ± 0.011"	2008.30	1.4 0.4	2007.596 2007.672 2009.619	JM SM GM	2
STF 670AB	6754	05167+1826	156.09 ± 0.25° 2.320 ± 0.0.14"	2014.22	n/a 0.04?	2014.184 2014.259	JM SM	3
STF1265	13263	08439+1337	311.32 ± 0.70° 5.690 ± 0.060"	2014.08	c2.3 2.45	2012.327 2015.840	DG TG	4
AGC 5AB	18997	13006-0322	181.32±6.94° 0.577±0.092"	2016.45	2.6±0.5	2016.453	GK, MF, BL	5
BU 929	19056	13039-0340	193.91±0.33° 0.634±0.019"	2016.45	0.20±0.15	2016.452	DG,GK,BL	6
STF1763AB	19549	13376-0752	59.71 ± 0.26° 1.833 ± 0.007"	2015.66	0.10 n/a 0.03	2015.484 2015.484 2016.007	DH, PA, RS	7
BU 126AB	23370	17199-1745	264.72 ± 1.24° 2.399 ± 0.028"	2016.69	1.4±0.2 1.61±0.05	2016.617 2016.842	DH, DG, JB, GK DH, DG	8
HDS2485AB	23712	17362-1752	88.50 ± 1.67° 0.717 ± 0.012"	2016.52	1.43 1.37 2.35 2.55	2015.796 2016.768 2016.768 2016.768	DH DH JB BL	9A
YSC 158Aa,Ab	23712	17362-1752	252.54 ± 7.00° 0.063 ± 0.009."	2016.28	1.09 0.43	2015.796 2016.768	DH BL	9B
HDS2486	23720	17369-1757	133.74 ± 4.43° 0.157 ± 0.003"	2016.28	1.31 1.73	2015.796 2016.768	DH DH	10
A 2256AB	24391	18011-1804	160.70 ± 2.38° 0.248 ± 0.059"	2015.42	0.53 0.55	2014.600 2016.246	DH DH	11
RST4095	30302	22018-0952	185.80 ± 0.17° 0.158 ± 0.001"	2016.33	0.53 0.48 0.75	2015.809 2016.408 2016.782	TG DG BL	12

Table 1 Notes

1. MCA 7 (31 Arietis) has a published orbit period 3.8 years. There is likely to have been noticeable change in the relative position of the pair between the two observations in August 2015 and the one in November 2015.
2. COU 560 Aa, Ab observations dating from 2007 and 2009. Any change in relative position of the pair is small.
3. STF 670 AB, SM magnitude difference not reliable due to image saturation. SM also detected the Ba,Bb pair.
4. STF1265, no significant change in relative positions expected in 3.5 years.
5. AGC 5 AB, all observations same date. Magnitude difference determinations variable. The mean is shown.
6. BU 929, All observations same date.
7. STF1763 AB, no significant change in relative positions expected in 7 months. Observation by PA was visual.
8. BU 126 AB, no significant change in relative positions expected in 3 months. Some magnitude estimates could be affected by image saturation.

9A. HDS2485 AB, separation expected to increase by 0.02" in the year between observations and the PA to increase by 0.3°. The magnitude difference is as determined from B relative to A+Aa,Ab. See next

9B. YSC158 Aa,Ab, A is the primary of HDS2485AB above. Magnitude difference is for Ab relative to A.

10. HDS2846, no significant change in relative positions expected in year between observations.
11. A 2256 AB, no significant change in relative positions expected in 19.5 months between observations.
12. RST4095, no significant change in relative positions expected during year covered by observations.

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Table 2. WDS: Single observation, Vector separation and magnitudes determined

WDS Star	XZ number	RA Dec	Observed Vector		Mag difference		Mags	Date	Obs
			Angle	Sep	Catalog	Observed			
LSC 4	122	00087-0213	59.8°	0.580″	n/a	3.80 ± 0.08	6.63 + 10.43	2017 Jan 4	TH
STT 18AB	885	00424+0410	209.8	1.53″	1.85	1.94 ± 0.15	7.85 + 9.79	2015 Nov 27	BL
SHN 61	1259	00573+0319	113.3°	0.398″	0.20	0.15 ± 0.15	10.82 + 10.97	2016 Dec 9	DH
J 683	8624	06146+1725	145.1°	1.144″	0.60	0.76 ± 0.02	8.77 + 9.53	2015 Mar 27	SM
TDS3669	85206	06153+1740	260.7°	1.214″	1.86	2.10 ± 0.10	9.82 + 11.92	2015 Mar 27	SM
A 2460	96107	06588+1847	236.5°	0.127″	0.70	0.89 ± 0.13	9.87 + 10.76	2016 Apr 23	DH
BU 899AB	10199	06592+1843	80.4° 70.7°	0.726″ 0.795″	0.82	1.25 ± 0.20 1.27 ± 0.08	8.95 + 10.20 8.94 + 10.21	2014 Feb 11 2016 Apr 13	BL DH
HEI 346	110218	08334+1318	128.6°	0.269″	0.22	0.84 ± 0.09	10.69 + 11.53	2015 Apr 26	SM
HEI 145BC	111328	08441+1357	308.6°	0.705″	0.20	0.21	10.1 + 10.3	2016 Apr 26	DH
HU 1251	13297	08452+1523	59.9°	0.672″	0.05	1.20 ± 0.18	9.75 + 10.95	2016 Apr 15	BL
HDS1867*	19292	13197-0632	159.2°	0.216″	1.81	1.60 ± 0.05	8.71 + 10.31	2015 Jul 15	DH
RST3853	19805	13539-0850	124.2°	0.336″	2.30	1.31 ± 0.12	9.86 + 11.17	2015 Aug 20	DG
STF1788AB	19816	13550-0804	168.4°	1.44″	0.58	0.76 ± 0.06	6.55 + 7.31	2016 Jun 15	DH
HU 262**	45748	19167-1739	287.7°	0.242″	0.42	0.31±0.07	9.70 + 10.71	2016 Oct 9	BL
HU 265	45924	19223-1719	47.3°	0.799″	0.11	0.06 ± 0.07	10.46 + 10.52	2016 Oct 9	DH
HLD 162	176151	20442-1342	130.5°	1.85	0.10	0.33 ± 0.11	10.71 + 11.04	2015 Sep 24	DH
STF2752AB	29304	21072-1355	184.6°	4.37″	2.70	2.65 ± 0.03	7.37 + 10.02	2016 Oct 11	DG
BU 475	30466	22126-0801	173.6°	0.60″	3.02	3.26 ± 0.11	7.26 + 10.58	2015 Oct 23	BL

* A third component was discovered for HDS1867 at the same observation. See TYC 4964-01230-1, Table 3B.

** A third component was discovered for HU 262 at the same observation. See TYC 6300-00884-1, Table 3B.

Table 3A: Occultation Discoveries: Separation and Position Angle Determined

Star name	OCC #	XZ	Position RA Dec	Measured PA° & Sepn.	Mean Date	Mag. diff.	Observn Dates	Observers
TYC 1251-00673-1 SAO 93803	579	5425	04109+1557	337.45±2.46° 0.076 ± 0.008″	2015.68	2.25 ± 0.5.	2015.677	AA, HA, MI
TYC 6268-00268-1 SAO 161233	1796	24944	18160-1736	295 ± 2° 0.031±0.001	2015.52	ca 1.	2014.751 2015.649 2016.172	DH BL BL
TYC 6270-00271-1 SAO 161468	1547	25286	18264-1805	303.56 ± 0.04° 0.185 ± 0.000″	2014.82	1.33 ± 0.1	2013.852 2016.771	DG, BL BL
TYC 6287-02359-1 SAO 162251	1570	26484	19094-1653	69.89 ± 6.69° 0.038 ± 0.003″	2015.39	1.48	2014.753 2015.875 2016.175	DG, SK BL BL
TYC 6312-00761-1	1813	46854	19468-1555	130.14 ± 1.08° 0.504 ± 0.007″	2014.45	1.10 ± 0.15	2013.182 2015.728	DG DH
TYC 5805-00714-1 SAO 164784	1670	30249	21590-1011	290.69 ± 4.48° 0.114 ± 0.011″	2014.55	n/a 0.15 0 nil	2009.226 2015.809 2016.408 2016.782	BL DB DG BL

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Table 3B. Occultation Discoveries: Vector separation only measured

Star name	OCC #	XZ	RA Dec	Vector Angle	Vector Sep.	Mag. diff.	Observn. Date	Obs.	Fig.
TYC 1219-01040-1	1814	3464	02350-1806	196.4°	0.068″	0.19	2006.621	SM	Fig 1
TYC 1853-01759-1	1818	72746	05095+2725	54.0°	0.036″	0.55	2006.704	SM	Fig 2
TYC 1889-00154-1	1825	8679	06163+2816	95.0°	0.150″	2.01	2006.706	SM	Fig 3
TYC 1337-00228-1	1800	9300	06334+1847	285.0°	0.049″	0.67	2015.758	BL	Fig 4
TYC 1351-00742-1	1807	100938	07236+1658	309.1°	0.408″	0.45	2015.911	SM	Fig 5
TYC 0808-00195-1	1804	109685	08281+1427	305.4°	0.036″	0.37	2015.764	MI	Fig 6
TYC 0808-00932-1	1803	109909	08304+1347	37.5°	0.007″	1.48	2015.316	SM	Fig 7
TYC 0808-00059-1	1815	110063	08318+1432	286.3°	0.056″	0.06	2016.288	SM	Fig 8
TYC 1393-00220-1	1816	13266	08441+1527	65.7°	0.011″	0.73	2016.289	BL	Fig 9
TYC 1393-00234-1	1817	13296	08452+1521	253.7°	0.012″	0.2	2016.289	BL	Fig 10
TYC 0822-00322-1	1805	113892	09155+1141	71.9°	0.050″	0.26	2015.767	MI	Fig 11
TYC 0825-01196-1	1820	114342	09212+1305	187.1°	0.104″	0.15	2016.365	DG	Fig 12
TYC 0269-01041-1	1821	16823	11114+0557	300.0°	0.442″	0.69	2016.521	BL	Fig 13
TYC 4964-01230-1	1794	19292	13197-0632	159.3°	0.301″	2.72	2015.558	DH	Fig 14
TYC 4965-01174-1	1793	126127	13219-0631	278.3°	0.027″	0.1	2015.558	DH	Fig 15
TYC 6223-00148-1	1797	138416	16574-1701	217.3°	0.222″	0.69	2015.719	DH	Fig 16
TYC 6223-00442-1	1799	138809	17006-1714	271.9°	0.103″	1.37	2015.720	DH	Fig 17
TYC 6227-00005-1	1812	22964	17020-2036	200.1°	0.011″	n/a	2013.100	DG	Fig 18
TYC 6239-01058-1*	1827	142496	17300-1755	319.9°	0.033″	0.19	2016.768	BL	Fig 19
TYC 6254-03434-1	1798	145483	17532-1734	79.6°	0.157″	0.24	2015.722	BL	Fig 20
TYC 6254-03171-1	1809	43133	17583-1756	83.4°	0.164″	0.11	2016.246	DH	Fig 21
TYC 6254-03200-1	1810	24316	17590-1747	303.4°	0.153″	2.14	2016.246	DH	Fig 22
TYC 6255-02137-1	1811	43212	18013-1746	141.1°	0.070″	0.35	2016.246	DH	Fig 23
TYC 6268-01305-1	1826	24889	18145-1816	281.9°	0.019″	1.09	2016.620	DH	Fig 24
TYC 6287-02363-1	1806	164973	19106-1657	279.1°	0.043″	0.5	2015.875	BL	Fig 25
TYC6300-00884-1	1828	45748	19167-1739	107.7°	0.044″	1.55	2016.733	BL	Fig 26
TYC 6297-00560-1	1801	167727	19246-1640	309.5°	0.201″	0.02	2015.801	BL	Fig 27
TYC 5240-01553-1	1808	30895	22413-0615	139.7° 135.0°	0.018″ 0.107″	1.3 2.2	2015.961	DH DG	Fig 28a Fig 28b
TYC 5246-00208-1	1802	31405	23153-0432	129.9° 141.4°	0.027″ 0.022″	0.50 0.89	2015.813	HS KM	Fig 29a Fig 29b
TYC 6268-02033-1	1822	43463	18107-1829	122.8° 120.2°	0.278″ 0.217″	2.65 2.35	2016.845	DH DG	Fig 30a Fig 30b
TYC 6287-00443-1	1823	45329	19045-1749	48.3°	0.079″	0.02	2016.848	DH	Fig 31
TYC 0027-00172-1	1824	1900	01224+0544	75.6° 85.7°	0.100″ 0.309″	0.84 n/a	2016.867 2003.999	DH TO	Fig 32 n/a

* TYC 6239-01058-1, OCC1827, confirming observations obtained by DH and BL, 2017 February 20

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Table 4. Companion not observed (possible double star, entry in WDS &/or IF Catalog.)

Star name	OCC #	XZ	RA Dec	Vector angle	Resolution limit	Limiting Mag. diff.	Observn Date	Observer
HD 472	124	132	00092+0004	6.5° 27.5°	0.015" 0.023"	3.0 1.5	2015.965 2015.965	SM RS
HD 27749	1231	5668	04234+1647	293.2° 69.0	0.023" 0.030"	2.3 2.3	1999.820 1999.970	RS RS
HD 27819	952	5687	04241+1727	260.3° 208.7° 113.8° 109.6°	0.034" 0.021" 0.031" 0.032"	3.3 2.8 3.3 2.1	2015.603 2015.603 2015.977 2015.977	DG BL DH DG
HD 45149	499	9054	06266+1749	57.8° 265.9°	0.020" 0.027	3.2 2.1	2015.160 2015.908	SM SM
HD 47916	930	9604	06417+1743	237.2° 43.5°	0.014" 0.016"	2.4 2.3	2013.815 2014.339	JM RS
HD 48029	1022	9626	06422+1847	118.0° 74.6°	0.023" 0.032"	3.5 2.5	2014.189 2015.134	DG DH
HD 54986	503	10640	07118+1659	356.3° 125.9°	0.003" 0.032"	1.9 2.8	2014.788 2016.060	RS AP
HD 61338	367	11486	07395+1740	106.6° 111.7° 302.5°	0.027" 0.028" 0.031"	3.1 n/a 2.7	2013.146 2013.146 2015.911	BL AL DH
HD 61998	344	11560	07426+1742	323.5° 302.9°	0.021" 0.028"	2.6 2.8	2015.912 2015.912	DG BL
HD 63496	929	11745	07498+1506	228.9° 150.0°	0.022" 0.016"	2.0 2.3	2013.744 2014.193	JM JM
HD 89112	7	15423	10169+0815	178.8° 192.6° 124.5° 97.4°	0.021" 0.014" 0.033" 0.026"	2.5 1.7 2.7 2.8	2009.338 2009.338 2015.547 2016.294	DG DH DG SM
HD 185571	530	27375	19403-1653	292.3° 20.0°	0.022" 0.014"	3.4 3.3	2012.358 2016.700	DG DH
HD 200212	914	29204	21024-1227	57.5° 114.6° 113.4° 248.2°	0.029" 0.018" 0.018" 0.036"	2.4 2.2 2.2 3.0	2011.913 2013.710 2013.710 2015.506	HW HW HA BL
HD 202309	972	29471	21152-1305	37.3° 103.3°	0.021" 0.036"	2.8 2.3	2010.793 2016.780	SM DH
HD 223928	125	32037	23537-0140	201.5° 63.5° 48.2°	0.030" 0.028" 0.034"	2.0 2.0 3.0	2006.613 2016.039 2016.787	SM RS DH

[The ‘Resolution limit’ is set at no less than two frame intervals [0.080s (PAL) or 0.067s (NTSC)] times the vector rate of motion.]

Table 5. Companion not observed (definite double star, listed in WDS)

Star name	XZ	RA Dec	Predicted-Mags	Predicted delta T	Limiting Mag. diff.	Observn Date	Observer
TDS 4760	100931	07235+1654	11.3+11.5	1.68 s	2.1	2015.911	SM
TDS7608	120071	11006+0629	10.7+10.9	1.41 s 1.41 s	3.0 1.5	2016.371 2016.371	DH BL
TDT 537	145085	17517-1742	11.2+11.3	1.55 s	2.5	2015.392	DH
TDT 781	154366	18179-1750	9.5+10.1	0.75 s	2.5	2016.172	DG
TDT1329	45703	19157-1729	10.7+10.9	1.17 s	1.9	2016.773	BL
TDT2438	28682	20380-2340	10.5+10.6	1.35 s	1.5	2006.678	SM

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The Figures

The figures present the discovery light curves of stars found to be double at a lunar occultation. In most cases there is only one observation, although a few had two but no solution was possible.

The horizontal axes, effectively time, show the frame number of the video. The vertical axes show the measured light intensity of the star in arbitrary units. In some cases measures have been made of the light intensity for each frame of the video recording, that is 30 frames per second for NTSC videos, 25 fps for PAL videos. Otherwise measures have been made for each field of the video, with two fields in a frame, giving 60 fields per second for NTSC or 50 for PAL.

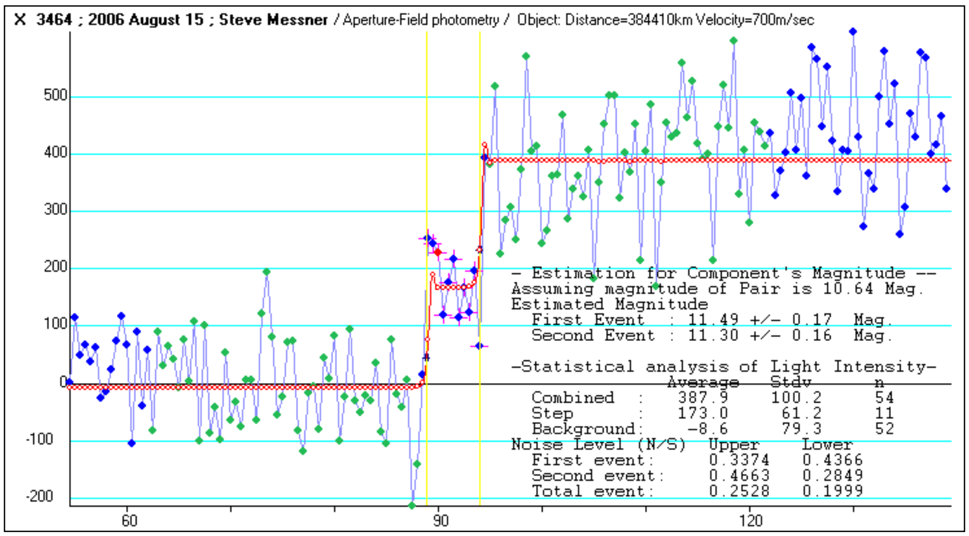

Figure 1. Light curve for the occultation reappearance of TYC 1219-01040-1 (XZ 3464) obtained by S. Messner. Measures have been made on each field of the video, 60 fields per second. The step lasts for 0.17 second, 10 fields. The fainter star was the first to appear from behind the moon. The heights of the step indicate a 0.19 magnitude difference between the components.

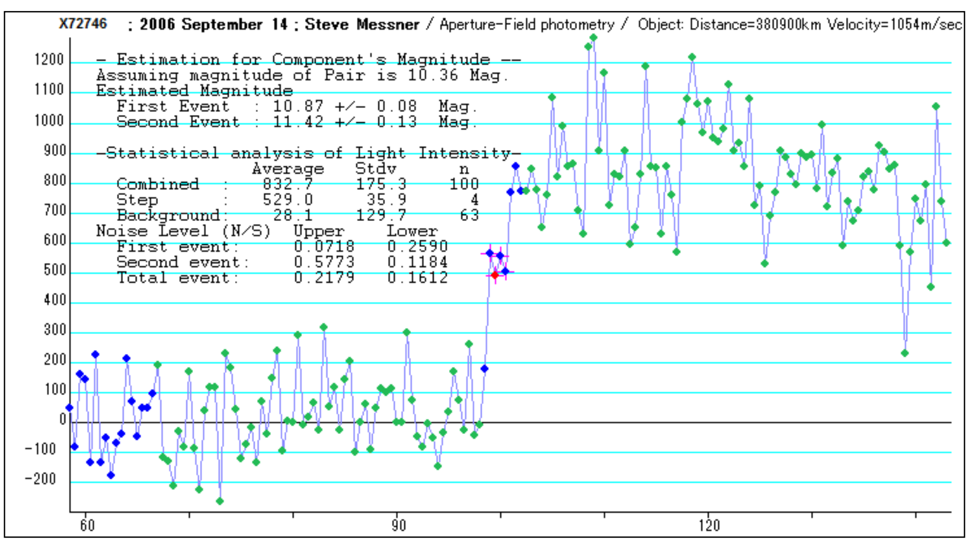

Figure 2. Light curve for the occultation reappearance of TYC 1853-01759-1 (XZ 72746) obtained by S. Messner. Light intensity measures have been made on each field. The step lasts for only 0.07 second. The brighter star was the first to appear from behind the moon. The heights of the step indicate a 0.55 magnitude difference between the components.

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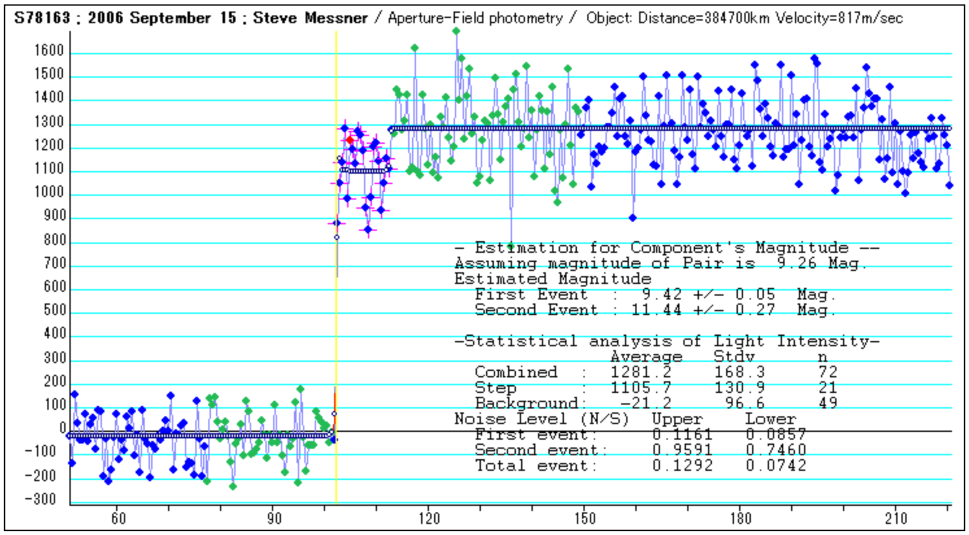

Figure 3. Light curve for the occultation reappearance of TYC 1889-00154-1 (SAO 78163) obtained by S. Messner. Light intensity measures have been made for each field. The step lasts for 0.35 second with the brighter star appearing first. The magnitude difference is about 2.0.

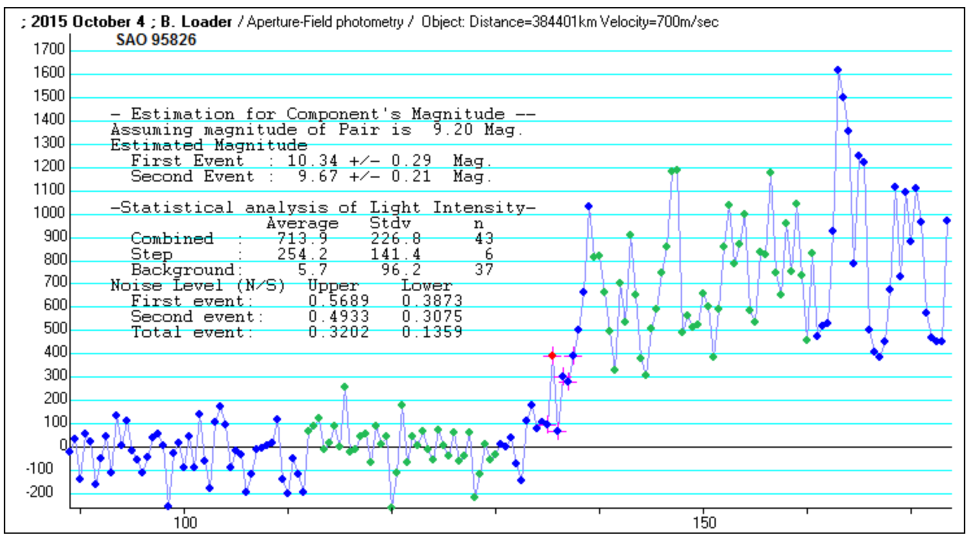

Figure 4. A rather noisy light curve obtained by B. Loader for the reappearance of TYC 1337-00228-1 (SAO 95826). Light intensity measures have been made for each field, 50 fields per second using a PAL camera. The step lasts for 0.12 s (6 fields), with the fainter star appearing first, the magnitude difference of the two components is about 0.67.

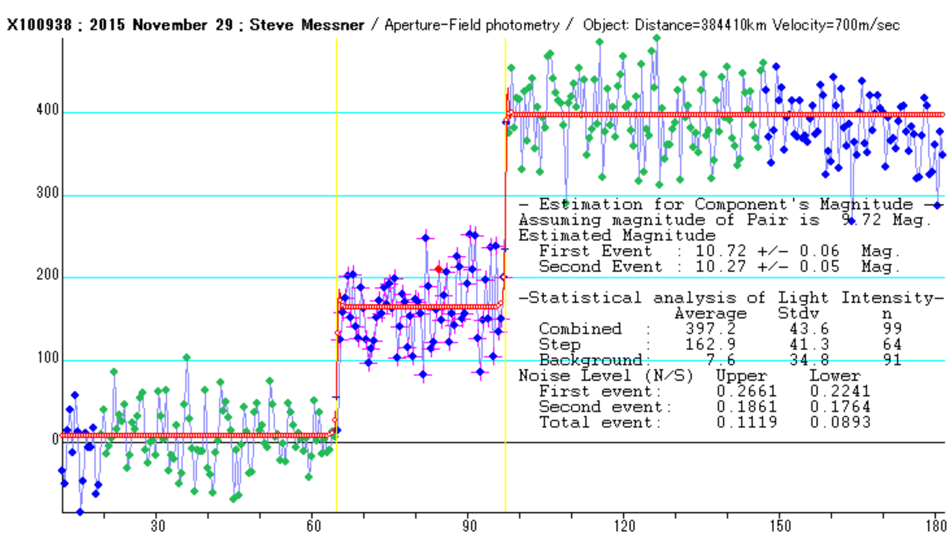

Figure 5. A clear step obtained by S. Messner at the occultation reappearance TYC 1351-00742-1 (XZ 100938). Light flux measures have been made at 60 per second, the step lasting for 1.14 s. The mean light levels indicate a magnitude difference of 0.45 with the brighter star appearing first.

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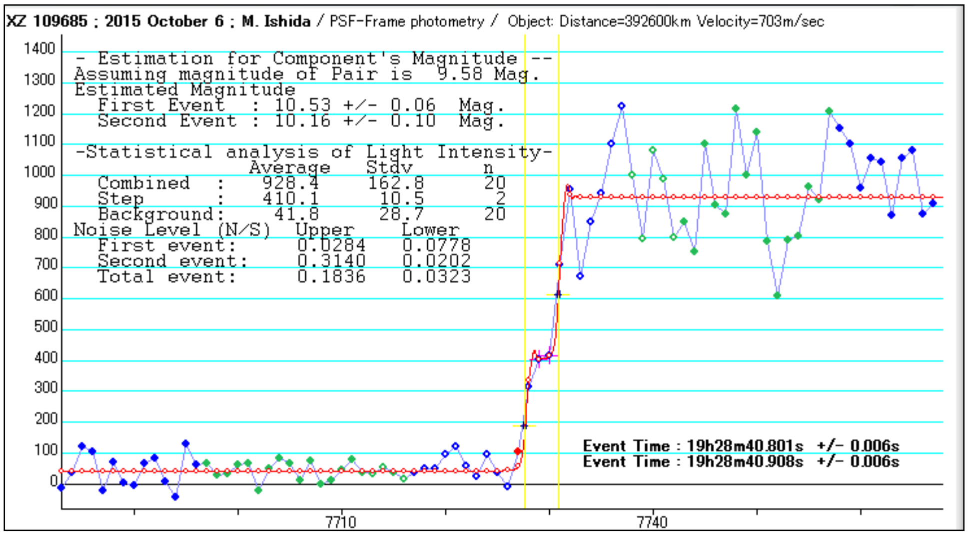

Figure 6. A brief step observed by M. Ishida for the occultation reappearance of TYC 0808-00195-1 (XZ 109685). Light flux measures have been made at 30 frames per second. The step lasts for some 0.11 seconds with the fainter star appearing first. The measured magnitude difference is 0.37.

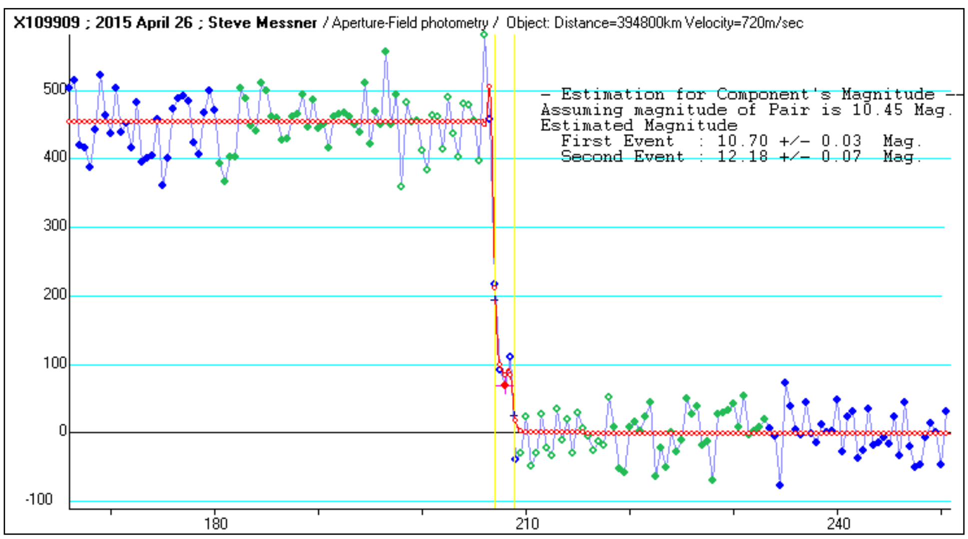

Figure 7: A very short step obtained by S. Messner at the occultation disappearance of TYC 0808-00932-1 (XZ 109909). This field measured step lasts for only 0.062 s, with the fainter star clearly the second to be occulted. The primary star to be the brighter by 1.48 magnitude.

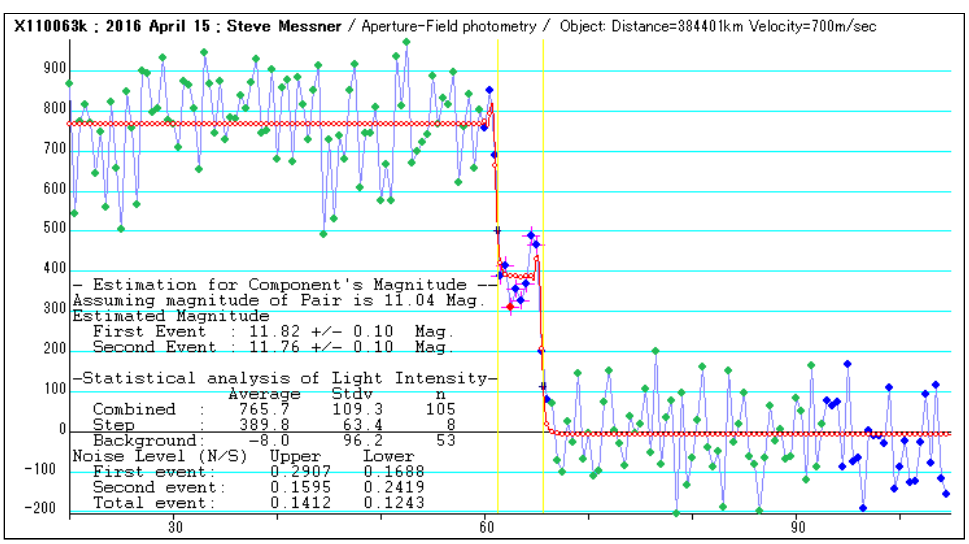

Figure 8. Light curve obtained by S. Messner for the occultation reappearance of TYC 1808-00059-1 (XZ 110063) with only a small magnitude difference, 0.06, between the component stars. The step lasts for 0.15 s, the fainter star appearing first.

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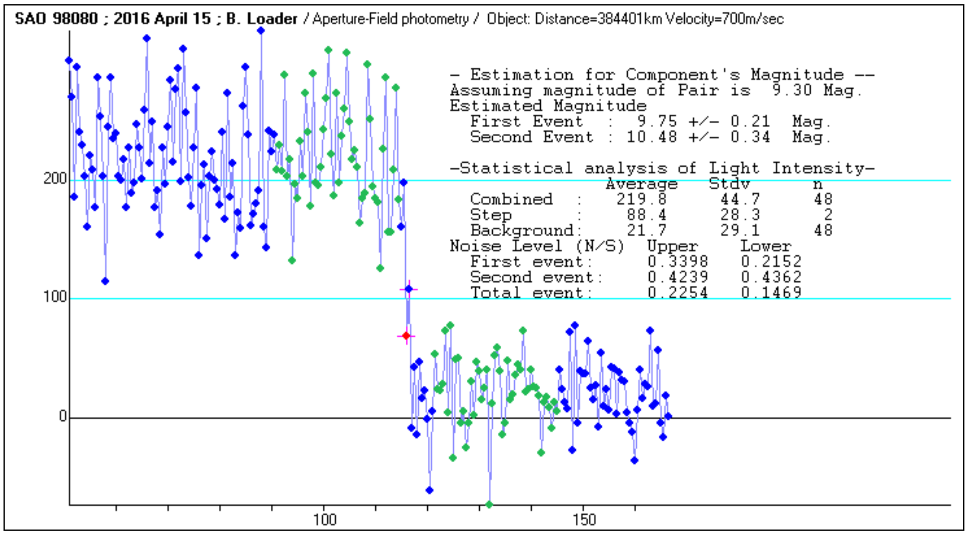

Figure 9. A very brief step observed by B. Loader for the occultation disappearance of TYC 1393-00220-1 (SAO 98080). The step lasts for 2 fields only, 0.04 s. The magnitude difference of the two components is about 0.73, the brighter star having been occulted first.

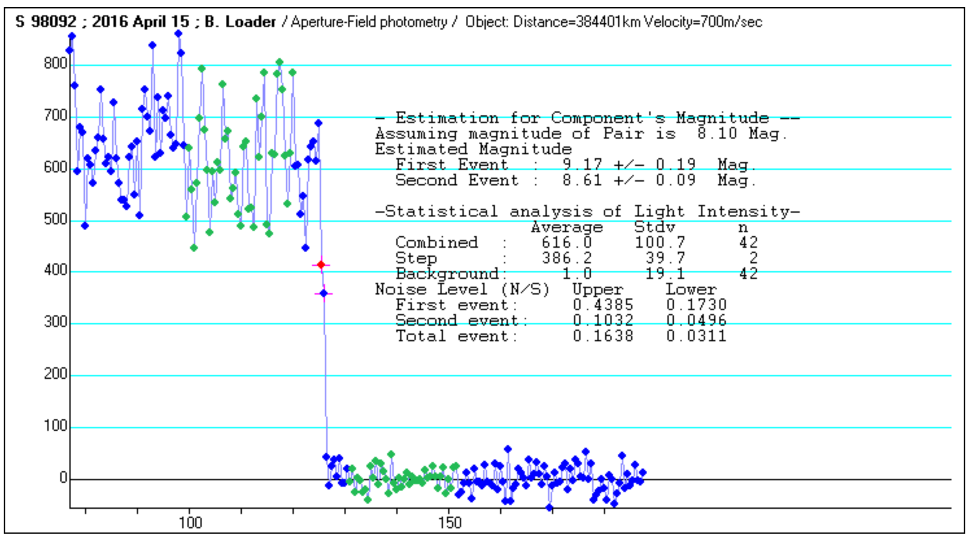

Figure 10. Another brief step observed by B. Loader, the disappearance of TYC 1393-00234-1 (SAO 98092). The 2 field step lasts 0.04 s, with the fainter star being occulted first. The magnitude difference is 0.56.

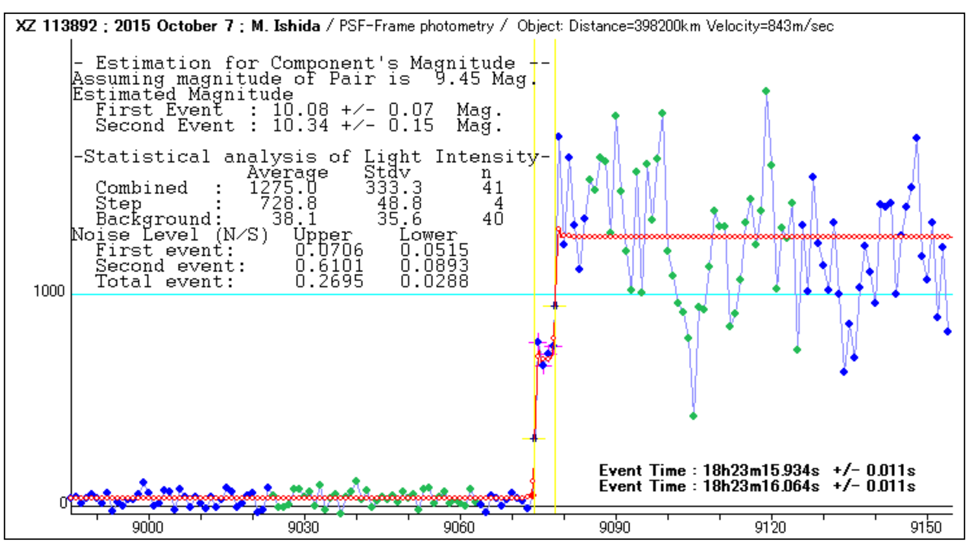

Figure 11. Light curve obtained M. Ishida at the occultation reappearance of TYC 0822-00322-1 (XZ 113892). The step lasts for 0.13 seconds with the brighter star appearing first. The difference in magnitude is 0.26.

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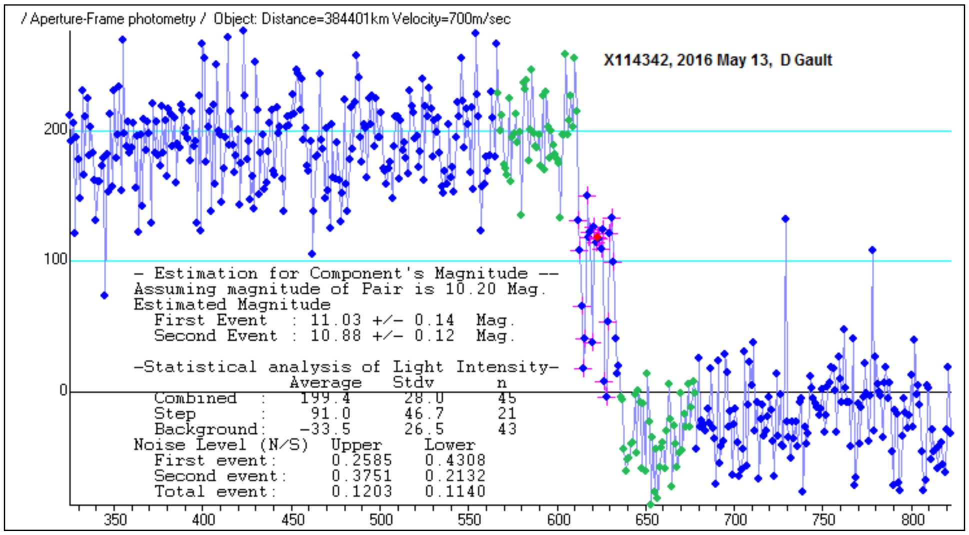

Figure 12. The light curve obtained by D. Gault at the occultation disappearance of TYC 0825-01196-1 (XZ114342). The step lasts for 1.06 second, the fainter star being occulted first. The difference in magnitude is calculated at 0.15 but there must be some doubt as to the accuracy due to the noise in the step. The difference could be as much as 0.6 magnitude.

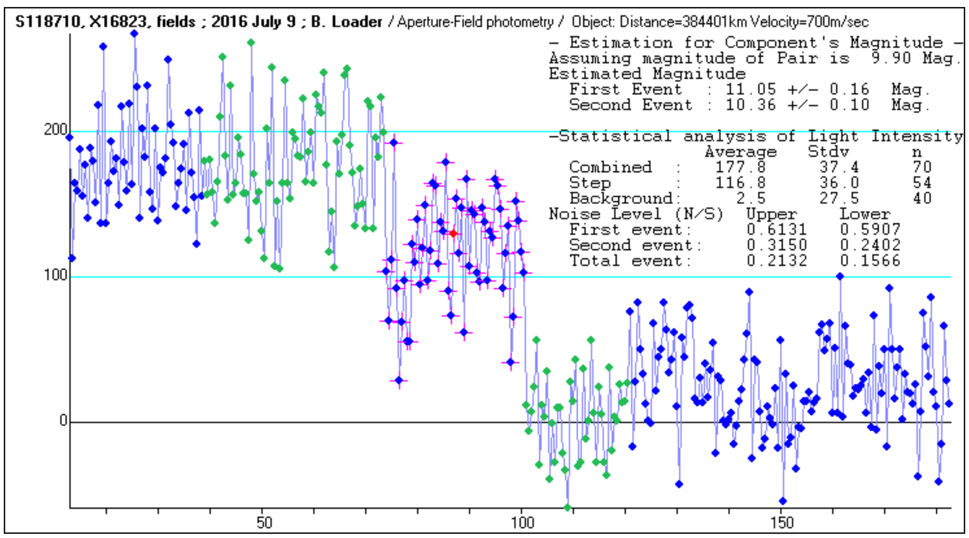

Figure 13. Light curve for the occultation of TYC 0269-01041-1 (XZ 16823) obtained by B. Loader showing a step lasting 1.10 s (55 fields). The magnitude difference of the two components determined by Limovie is 0.69 with the fainter star occulted first.

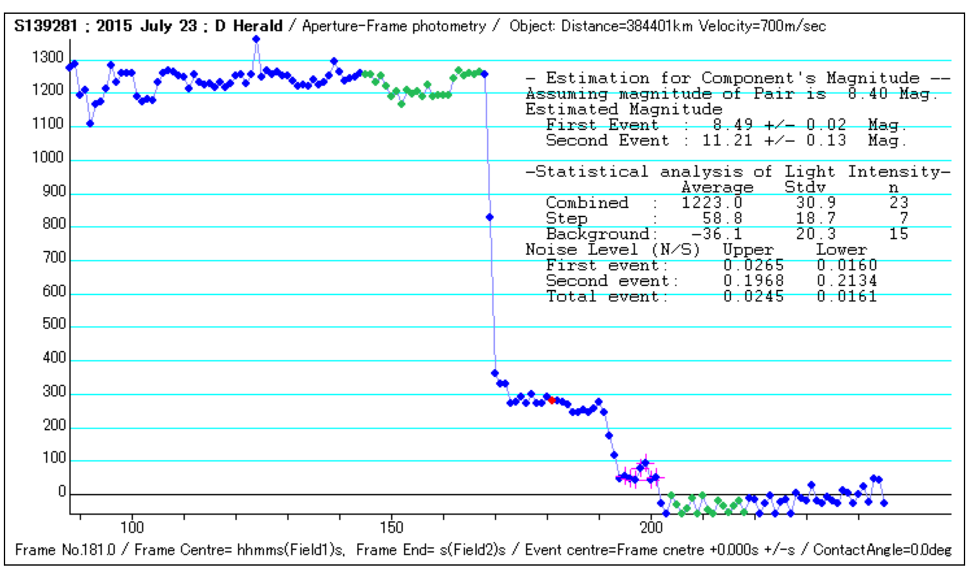

Figure 14. Light curve for the occultation disappearance of TYC 4964-01230-1 (SAO 139281) obtained by D. Herald. The main step is for the double HDS1867. The light curve shows the presence of a third component discovered at this event. The total duration of the two steps 1.28 s, the first step lasting 0.92 s and the second 0.36 s. The difference in magnitude of the faintest component compared to the two brighter components combined is 2.72.

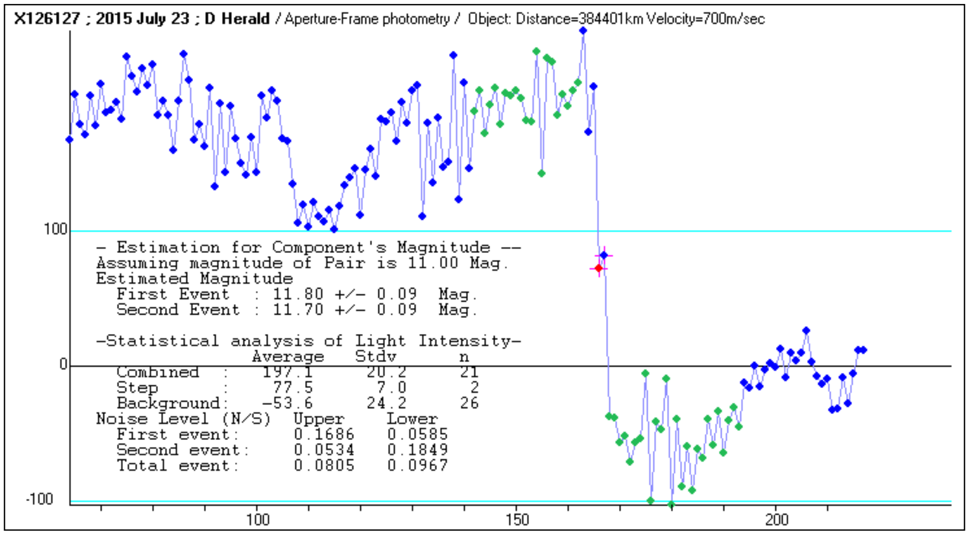

Figure 15. Light curve obtained by D. Herald at the occultation of TYC 4965-01174-1 (XZ126127). There is a brief 2 frame step for 0.08 s with the fainter star disappearing first. The magnitude difference is only 0.10.

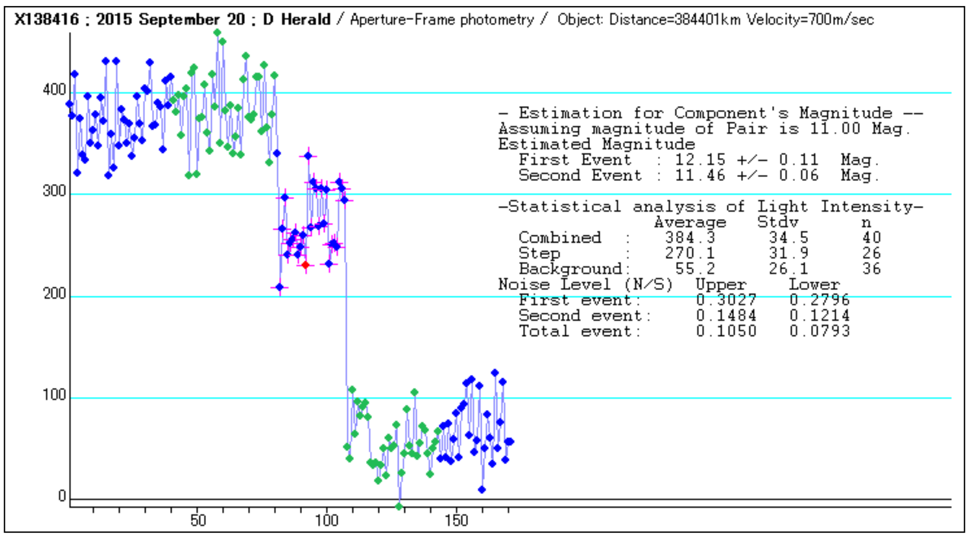

Figure 16. Light curve obtained by D. Herald at the occultation of TYC 6223-00148-1 (XZ138416). This step lasts for 1.04 s, 26 frames. The fainter star was clearly occulted first, the magnitude difference being 0.69.

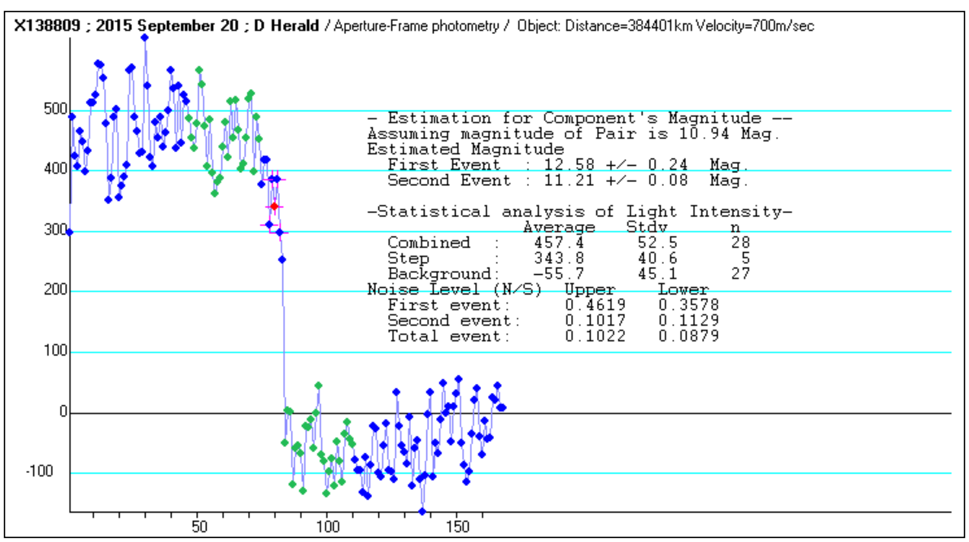

Figure 17. Light curve obtained by D. Herald at the occultation of TYC 6223-00442-1 (XZ138809). The step lasts for 0.24 second, the fainter star clearly disappearing first. The magnitude difference is 1.37

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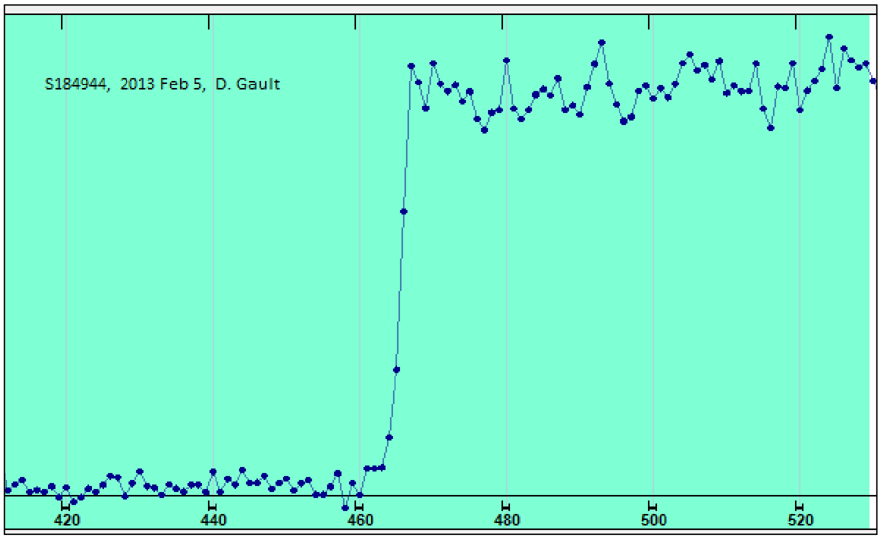

Figure 18. A possible 3 frame, 0.12 s, step observed by D. Gault at the occultation reappearance of TYC 6227-00005-1 (SAO 184944). If the step is real, there is a 3 magnitude difference between the two stars.

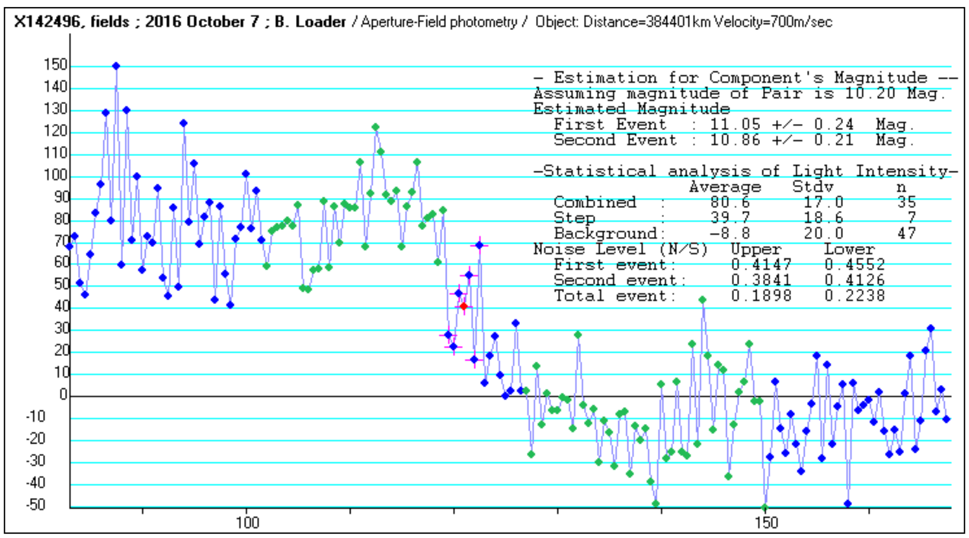

Figure 19. A noisy light curve obtained by B. Loader at the occultation of TYC 6239-01058-1 (XZ142496). The fainter star was occulted first, the step lasting for 0.14 second, 7 fields at 50 fps. The magnitude difference is 0.19 with a moderate error due to the noise.

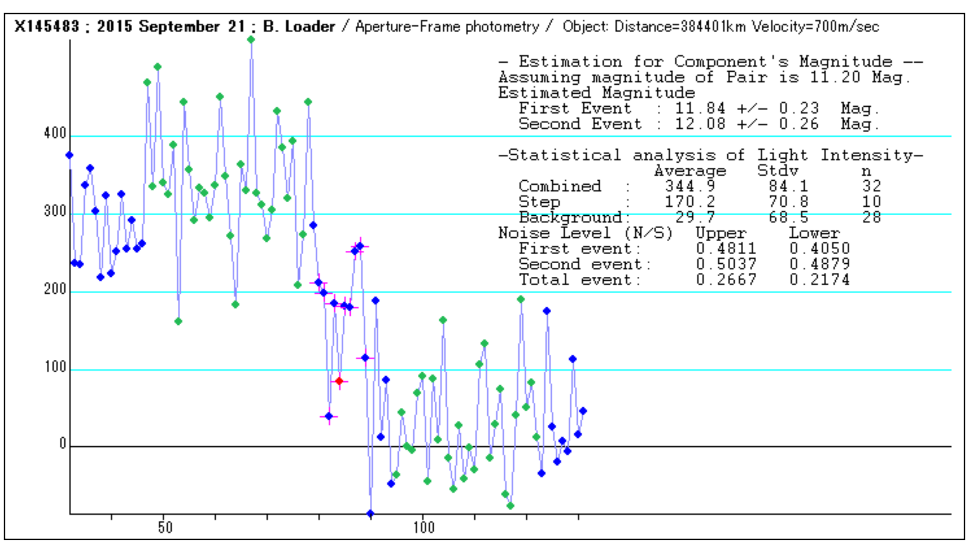

Figure 20. Another noisy light curve obtained by B. Loader at the occultation of TYC 6254-03434-1 (XZ145483). There is a likely step lasting for 0.34 s with the brighter star probably occulted first. The measured magnitude difference is 0.24 but with an error of the same order of size

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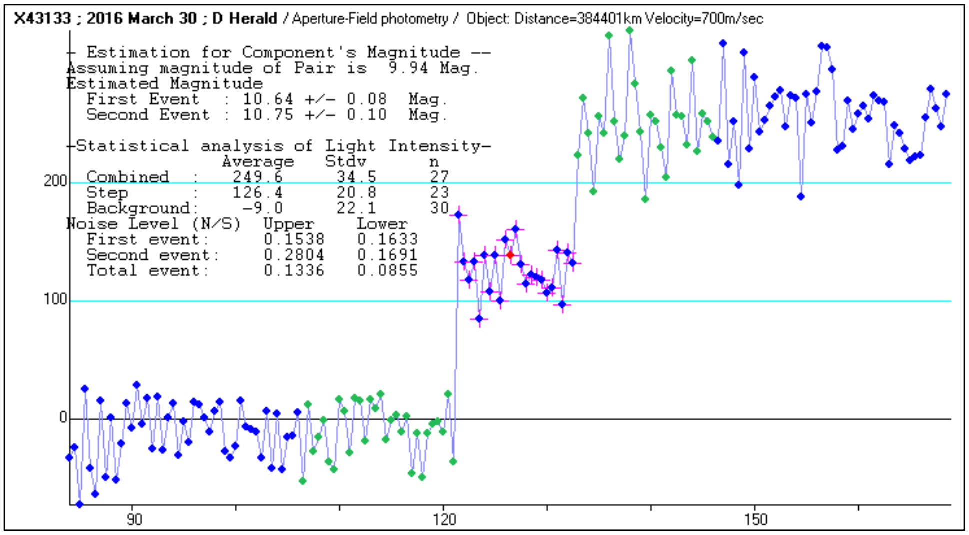

Figure 21. The light curve obtained by D. Herald at the occultation reappearance of TYC 6254-03171-10 (XZ43133) shows a clear step lasting 0.46 s. The light curve has been analyzed using field measures (50 fps) and shows only a small difference of 0.11 between the two stars of the double.

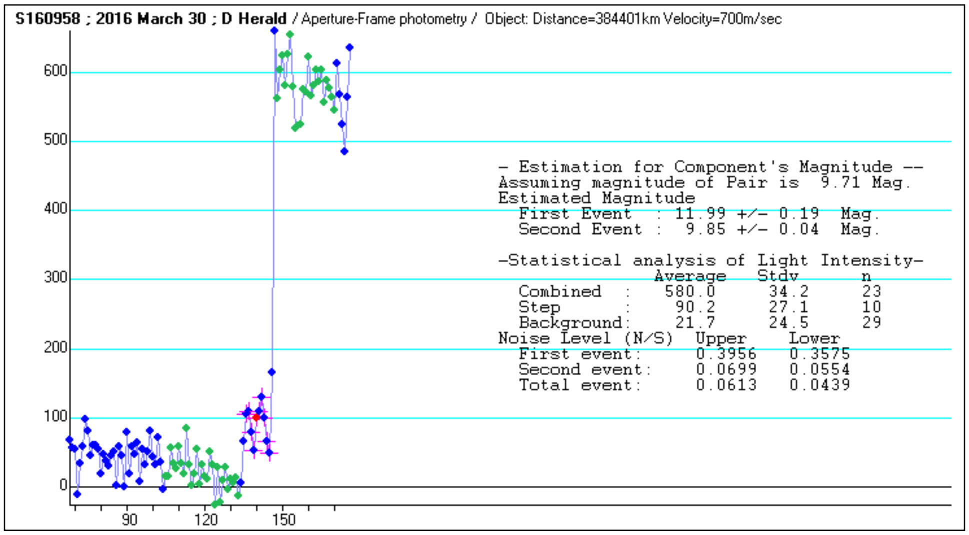

Figure 22. Light curve obtained by D. Herald for the occultation of TYC 6254-03200-1 (SAO160958). The step lasts for 0.48 s, the fainter star being the first to appear. The light levels measured by Limovie suggest a 2.14 magnitude difference between the two components.

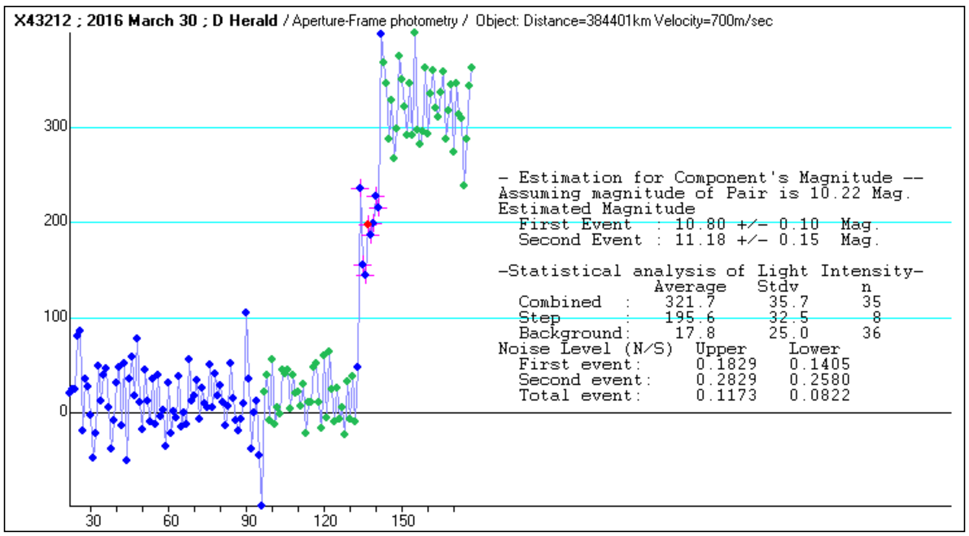

Figure 23. Light curve obtained by D. Herald at the reappearance from occultation of TYC 6255-02137-1 (XZ43212). The step lasts for eight video frames, 0.32 s. From the light curve it appears the fainter star was the second to appear from behind the moon, the light levels suggesting a 0.28 magnitude difference between the component stars.

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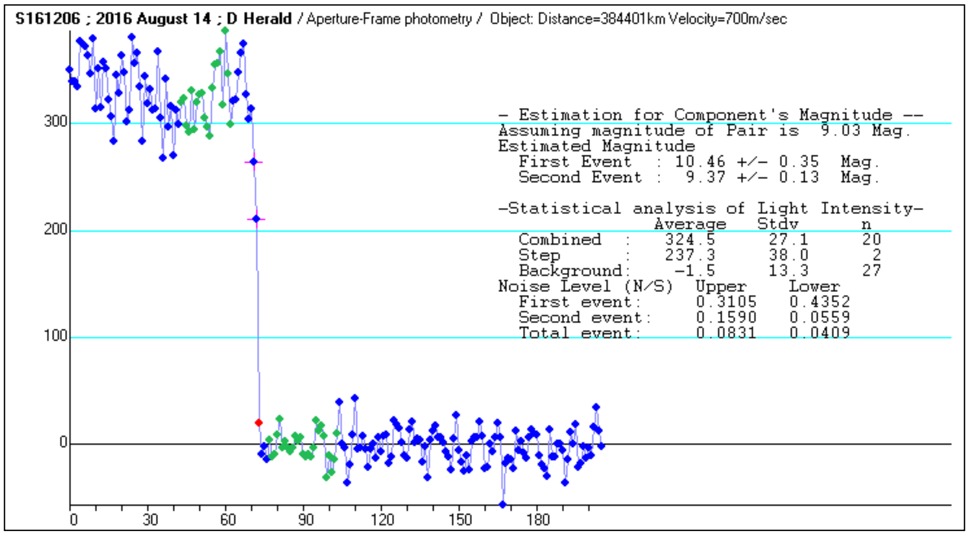

Figure 24. Light curve obtained by D. Herald at the occultation disappearance of TYC 6268-01305-1 (SAO161206). The step is very brief lasting for 0.06 s with the fainter star occulted first. The magnitude difference of the components is estimated at 1.09.

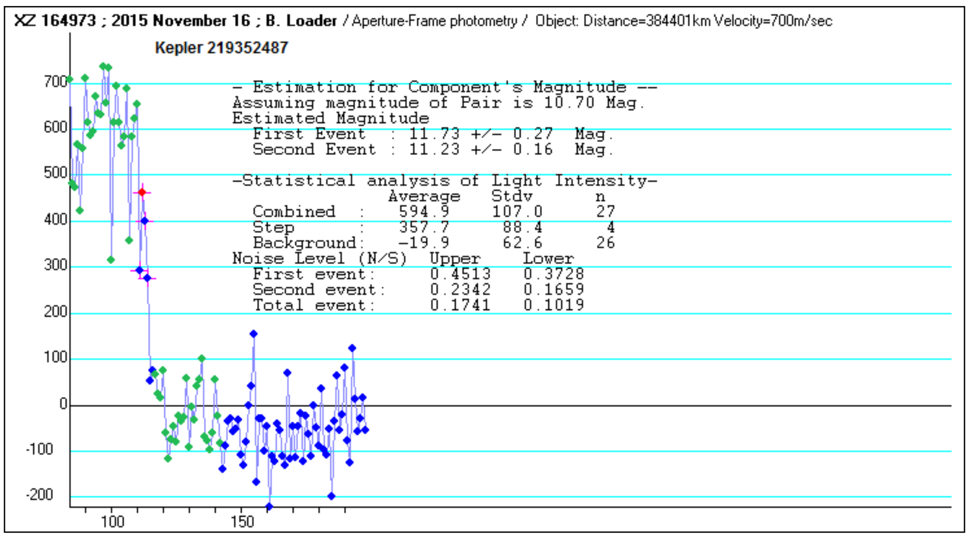

Figure 25. Light curve obtained by B. Loader at the occultation disappearance of TYC 6287-02363-1 (XZ164973). The fainter star was the first to be occulted, followed 0.09 s later by the brighter star. The light levels determined by Limovie indicate a 0.50 magnitude difference between the two stars.

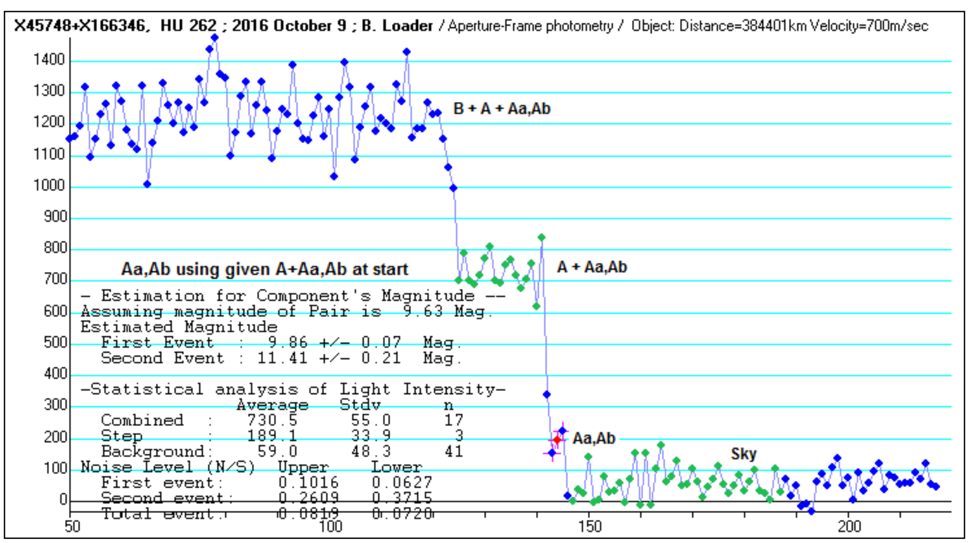

Figure 26. Light curve obtained by B. Loader at the occultation disappearance of TYC 6300-00884-1 (XZ 45748). The star is a known double, HU262, the light curve shows the star is apparently triple. The main step occurs first but is followed by a brief step indicating the third component discovered at this occultation. This step lasts for 0.13 s with the fainter newly discovered component being the last to disappear. The estimated magnitude difference from the brightest component is 1.55.

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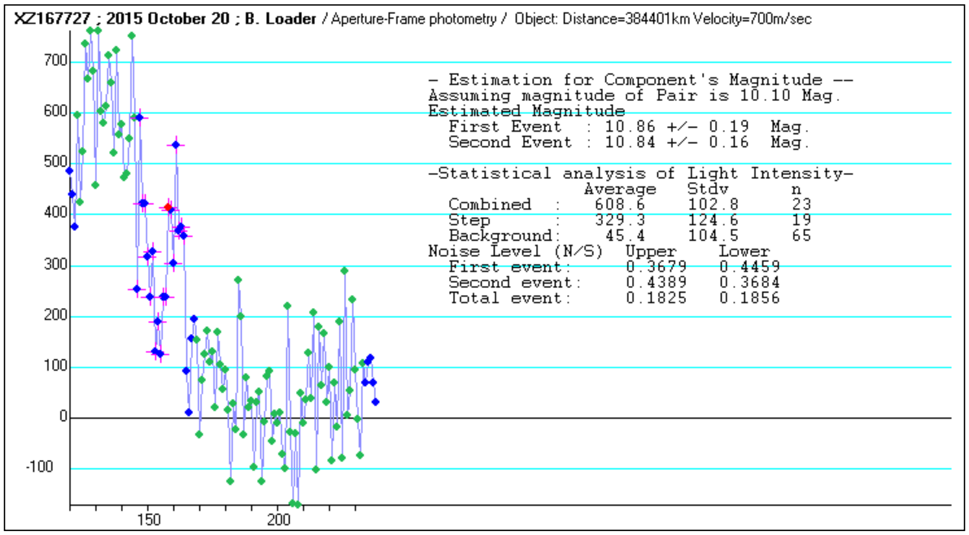

Figure 27. Light curve obtained by B. Loader at the occultation disappearance of TYC 6297-00560-1 (XZ167727). The step lasts for 0.78 seconds. The two components appear to be similar in magnitude, the calculated 0.02 magnitude difference is not significant, so the order of disappearance is uncertain.

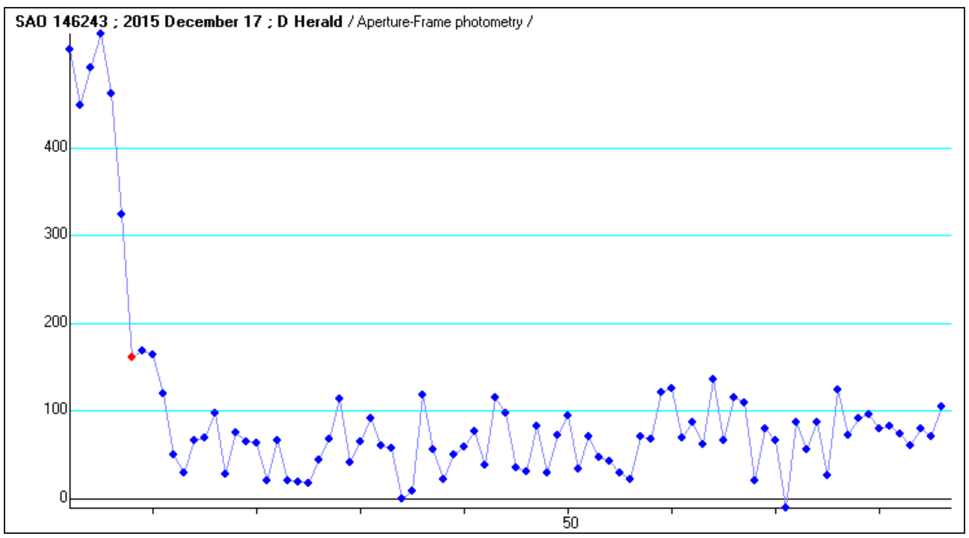

Figure 28A. Light curve obtained by D. Herald for the occultation disappearance of TYC 5240-01553-1 (SAO146243). A brief 3 frame step is shown, equivalent to a duration of 0.12 second. The brighter star is the first to be occulted. Unfortunately the lead in time is very short and the magnitude difference in the components is uncertain. An estimate is 1.3. This event was also observed by D. Gault but the limb PAs of the two observations are too close to obtain a reliable solution.

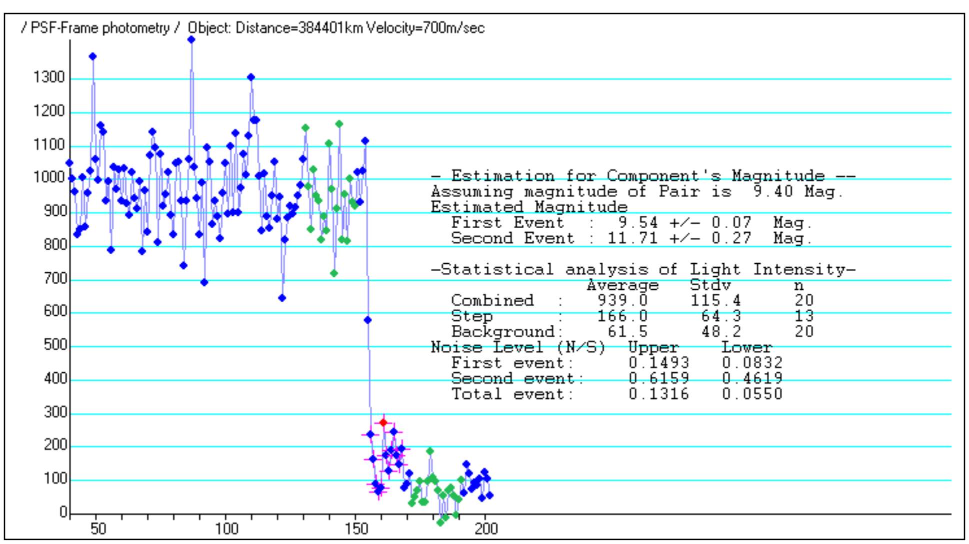

Figure 28B. Light curve obtained by D. Gault for the occultation disappearance of TYC 5240-01553-1 (SAO146243). Gault's step duration is considerably longer than Herald's which seems surprising considering the two events were less than 5° apart on the moon's limb. A probable explanation is differences in limb topography at the points of occultation which is considerably more pronounced for Herald's event.

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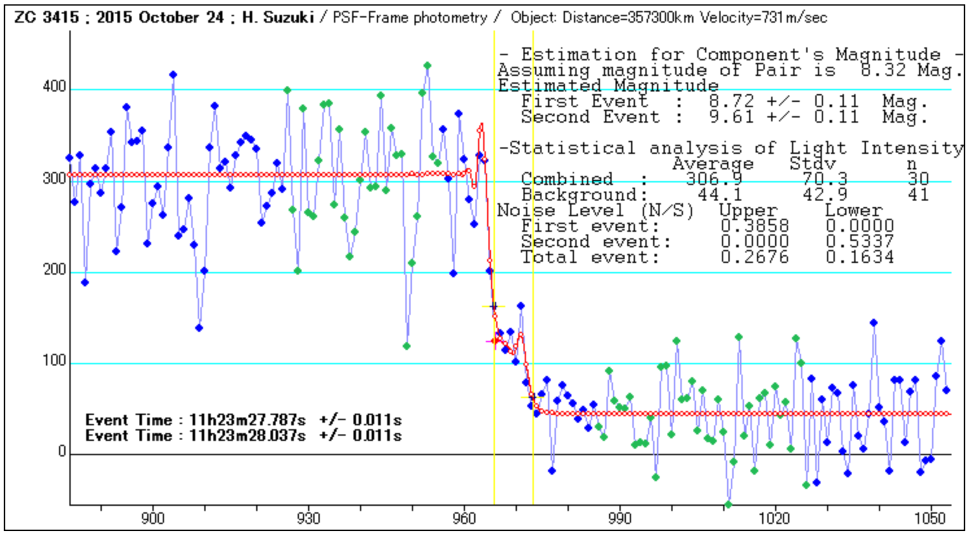

Figure 29A. Light curve obtained by H. Suzuki for the occultation disappearance of TYC 5246-00208-1 (ZC 3415). The light curve shows a lasting for 0.250 s with the brighter star disappearing first. The magnitude difference of the two components is 0.89.

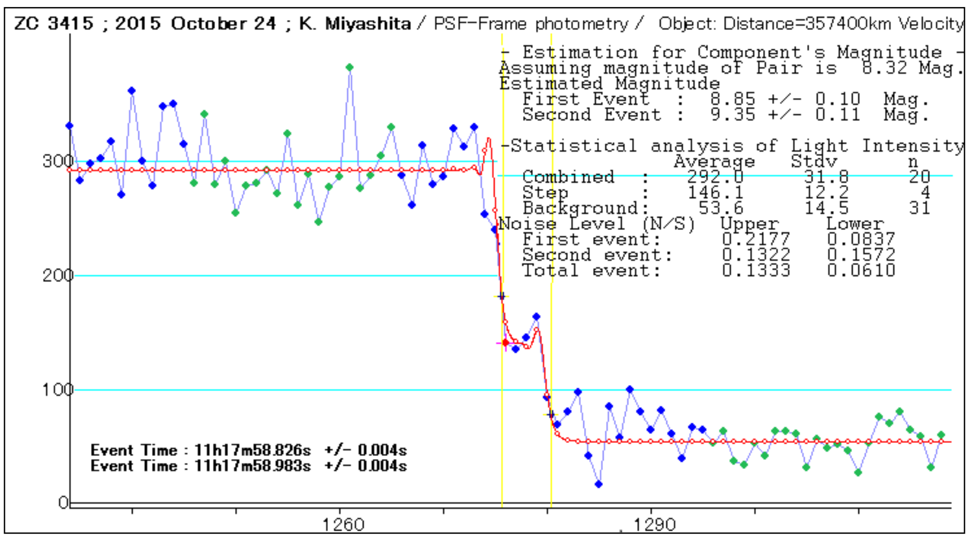

Figure 29B. Light curve obtained by K. Miyashita for the occultation disappearance of TYC 5246-00208-1 (ZC 3415). The light curve shows a step lasting for 0.157 s with the brighter star disappearing first. In this case the apparent magnitude difference of the two components is 0.50.

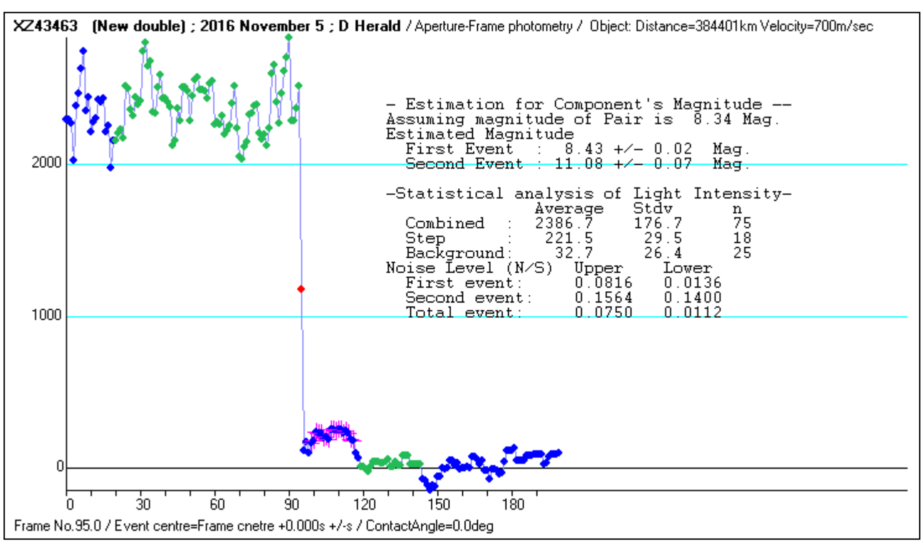

Figure 30A. Light curve obtained by D. Herald for the occultation disappearance of TYC 6268-02033-1 (XZ 43463). The curve shows a step lasting 0.86 s with the brighter star clearly disappearing first. The apparent magnitude difference of the two components is 2.65.

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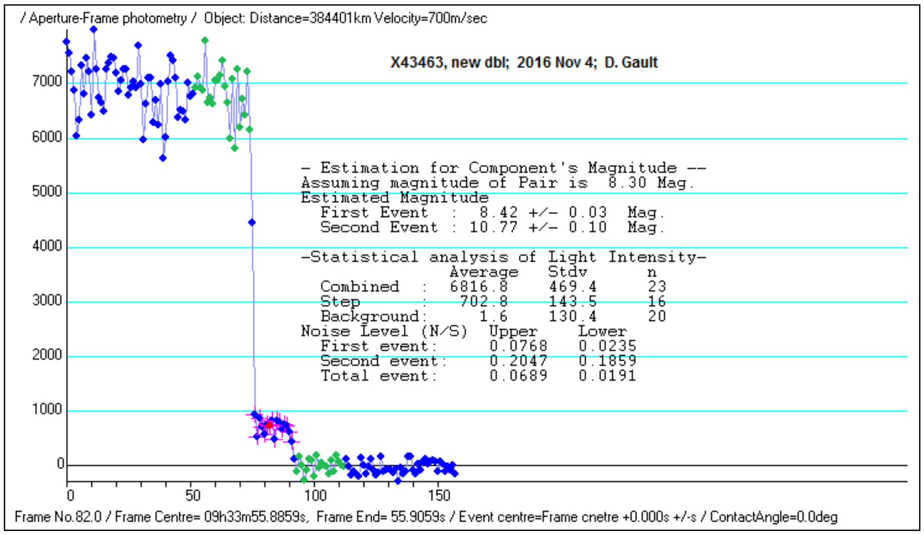

Figure 30B. Light curve obtained by D. Gault for the occultation disappearance of TYC 6268-02033-1 (XZ 43463). The curve shows a step lasting 0.64 s with the brighter star clearly disappearing first. The apparent magnitude difference of the two components is 2.35.

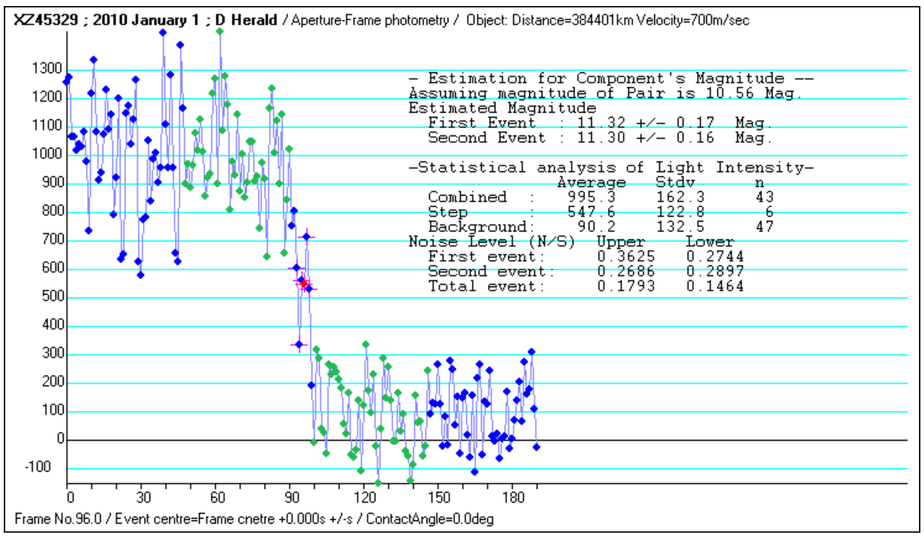

Figure 31. A somewhat noisy light curve obtained by D. Herald for the occultation disappearance of TYC 6287-00443-1 (XZ 45329). The curve shows a step lasting 0.86 s but the order is uncertain. The magnitude difference of the two components is 0.02. Given the errors in the magnitudes, the order of events is in doubt.

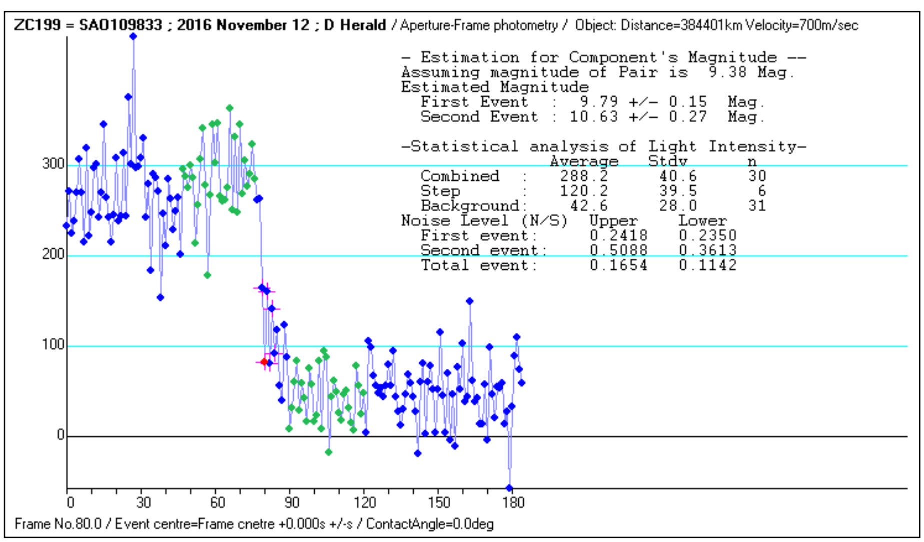

Figure 32. Light curve obtained by D. Herald for the occultation disappearance of TYC 0027-00172-1 (SAO 109833). The curve shows a step lasting 0.24 s with the brighter star clearly disappearing first. The rather uncertain magnitude difference of the two components is 0.84. The earlier, 2003, observation by T. Oono acts as a confirmation of the double, but there is no light curve available. The observation was recovered from archive by D. Herald.