Southern Eclipsing Binary Minima and Light Elements in 2020

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Abstract We present 246 times of minima of 77 southern hemisphere eclipsing binary stars acquired in 2020. These observations were acquired and analyzed by the authors, who are members of the Southern Eclipsing Binary group of Variable Stars South (VSS) (http://www.variablestarssouth.org), using CCD detectors. For four of the systems we have derived updated light elements and present those as well as O–C values for the VSS minima. This paper is the sixth in a series by Richards *et al.*

1. Observations

Equipment and software used are set out in Table 1. Observer initials abbreviate the name of an author of this paper, surname last. Instrument refers to the telescope and objective diameter in cm and the camera used. Remaining columns refer to the software used for the purposes listed.

All observers using PERANSO (Paunzen and Vanmunster 2016) employed polynomial fitting for minima estimation. Minima25 (Nelson 2019) estimates the time of an eclipse minimum (with standard deviation) by six methods: parabolic fit, tracing paper, bisectors of chords, the Kwee-van Woerden method (Kwee and Van Woerden 1956), Fourier fit, and sliding integrations. Then the mean of the individual minimum estimates is calculated, weighted by the standard deviation of each, which is returned together with its standard error as the best estimate.

Online information and sources for the software in Table 1 are as follows. In all cases the current versions of the software were used.

AstroImageJ (Collins *et al.* 2017)
https://www.astro.louisville.edu/software/astroimagej/

Astrophotography Tool (Incanus Ltd. 2009–2021)
https://www.astrophotography.app/

IRIS (Buil 1999–2018)
http://www.astrosurf.com/buil/iris-software.html

MaxIm DL (Diffraction Limited 2012)
http://www.cyanogen.com

Minima25 (Nelson 2019)
http://www.variablestarssouth.org

Muniwin (Motl 2011)
http://c-munipack.sourceforge.net

PERANSO (Vanmunster 2013)
http://www.peranso.com

TheSkyX (Software Bisque 2020)
http://www.bisque.com

VStar (Benn 2013)
https://www.aavso.org/vstar

Table 1. Observers, equipment, and software.

Observer	*Instrument*	*Imaging*	*Calibration*	*Photometry*	*Minima*
TR	41 cm R-C + SBIG STXL-6303e	MaxIm-DL	Muniwin	Muniwin	PERANSO
RA	12-cm refractor + ZWO ASI1600MM CMOS	Astrophotography Tool	AstroimageJ	AstroimageJ	VStar
MB	8-cm refractor + Atik One 6.0	TheSkyX Professional	MaxIm-DL	MaxIm-DL	PERANSO
MB	35-cm R-C + SBIG STT-3200	TheSkyX Professional	MaxIm-DL	MaxIm-DL	PERANSO
RJ	25 cm GSO RCA + QSI-583 CCD.	MaxIm-DL	MaxIm-DL	MaxIm-DL	Minima25e
DM	36-cm S-C + Moravian G3-6303 CCD	MaxIm-DL	MaxIm-DL	MaxIm-DL	PERANSO

Observers: TR, T. Richards; RA, R. A. Axelsen; MB, M. Blackford; RJ, R. Jenkins; DM, D. J. W. Moriarty.

Image sets were obtained in hours-long runs. Each observer analyzed their own image sets as follows:

1. Calibrated them using bias frames, dark frames, and flat field frames.

2. Executed differential aperture photometric measurements on the calibrated sets.

3. Performed minima estimation on the photometric data.

2. Results

Appendix A lists the minima estimates. Columns 1 and 2 list the GCVS designation of the target stars in lexical order of constellation abbreviation, and GCVS variability type as listed in (Samus *et al.* 2017). In some cases, more recent work may propose different variability types. Columns 3 and 4 record the heliocentric Julian dates of minima and the uncertainty (in days) as reported by the algorithm used in the photometry software. Column 5 lists the minimum type, primary (P) or secondary (S). We define the primary minimum as the deeper one in our observations where that can be determined, otherwise we assume the epoch recorded in the AAVSO Variable Star Index (Watson *et al.* 2006)—hereafter referred to as VSX—is of a primary minimum. Column 6 gives the filter used: B and V are Johnson B and V, R, and I are Cousins R and I, and SR is Sloan r'. Column 7 gives the initials of the observer.

3. Analysis

Following our practice in these series of papers we list revised light elements (aka ephemerides) for binaries in Appendix A for which we have derived four or more primary minima in this year (2020) and earlier years, spread over at least three observing seasons. The purpose of this is to see if there's good evidence for period change.

This year there are four such binaries. Their earlier minima estimates are listed in Table 2. Its last column cites the year of publication of the paper in this series (Richards *et al.* 2018, 2019, 2020) in which the estimate is recorded. Binaries with revised light elements reported in earlier papers in this series are excluded from the present paper.

Table 3 contains the resulting linear light elements for the systems we analyzed. These were derived by ordinary least squares regression. The regression used all the VSS primary minima times and the VSX epoch time as minima data. The VSX epoch and period were used as reference ephemeris to obtain an orbital cycle count for the minima data. By regressing the (HJD) minima times against cycles we obtained a best-fit period from the slope of the regression line, and a new zero epoch as the y-intercept at the earliest VSS minimum.

The first five columns list the system, the epoch and its standard error, the period and its standard error. The next column records the standard deviation of the residuals of the minima from the regression prediction. The smaller the number, the better are the minima data fitted to a linear fit (constant period). No. Obs. is the number of VSS primary minima estimates used in the regression, and Interval is the time interval in days covered by them.

For each system in Table 2, we present in Figure 1 plots of the residuals of the observed minima from the calculated regression (O–C values). The regression is represented by the horizontal line at O–C = 0. The left-hand panel in each pair for a star shows (by the left edge) the VSX minimum, together with (near the right edge) the VSS minima. The latter are zoomed into in the right-hand panel to exhibit any structure in the residuals which may indicate variation in the period. The error bars are those reported for the time of minimum by the software used for minima estimation.

The primary interest in the Table 3 light elements, and the Figure 1 residual plots, lies in indication of period change. In all four cases, the linear periods in Table 3 are inadequate fits to the data, and hence so are the VSX periods.

V901 Cen may have a decreasing period, but the minima estimates show significant scatter, probably indicative of RS CVn-type chromospheric disturbances shifting minima estimates slightly. An inspection of its photometric light curves shows that the occultation of one star is sometimes deeper, sometimes shallower than for the other star.

For *YY Eri*, while the VSS data are closely linear, the extreme slope is likely spurious, indicating a cycle count jump (Richards 2021) rather than a shorter period. An ephemeris using just the VSS data would plainly give the VSX data point an enormous residual, so such an ephemeris must be wrong.

Table 2. Minima estimates from earlier years used to construct the revised linear ephemerides in Table 3.

Identifier	*HJD of Min.*	*Error*	*Paper*
V901 Cen	2457806.0622	0.0002	2018
V901 Cen	2457849.9859	0.0002	2018
V901 Cen	2458195.96908	0.0013	2019
YY Eri	2458462.16282	0.00010	2019
YY Eri	2458846.02929	0.0013	2020
V Gru	2458362.9813	0.0038	2019
V Gru	2458376.9984	0.0026	2019
V Gru	2458678.20098	0.00031	2020
V Gru	2458727.99620	0.00010	2020
BS Mus	2458188.09221	0.00027	2019
BS Mus	2458204.22829	0.00020	2019
BS Mus	2458221.12957	0.00020	2019
BS Mus	2458228.04311	0.00019	2019
BS Mus	2458231.11474	0.00014	2019
BS Mus	2458576.07301	0.00018	2020

Table 3. Revised linear light elements for systems with four or more VSS primary minima estimates, regressed from the VSX light elements.

Identifier	E_0	E_{0err}	*P*	P_{err}	SD_{resid}	*No. Obs.*	*Interval*
V901 Cen	2452443.50036	0.0010	0.35423330	6.7E-08	0.0010	5	1442
YY Eri	2458462.15812	0.0018	0.3215000	3.0E-07	0.0039	4	730
V Gru	2458362.97649	0.006	0.4834461	5.4E-07	0.0147	5	715
BS Mus	2458188.10910	0.005	0.7682422	3.7E-07	0.0152	11	816

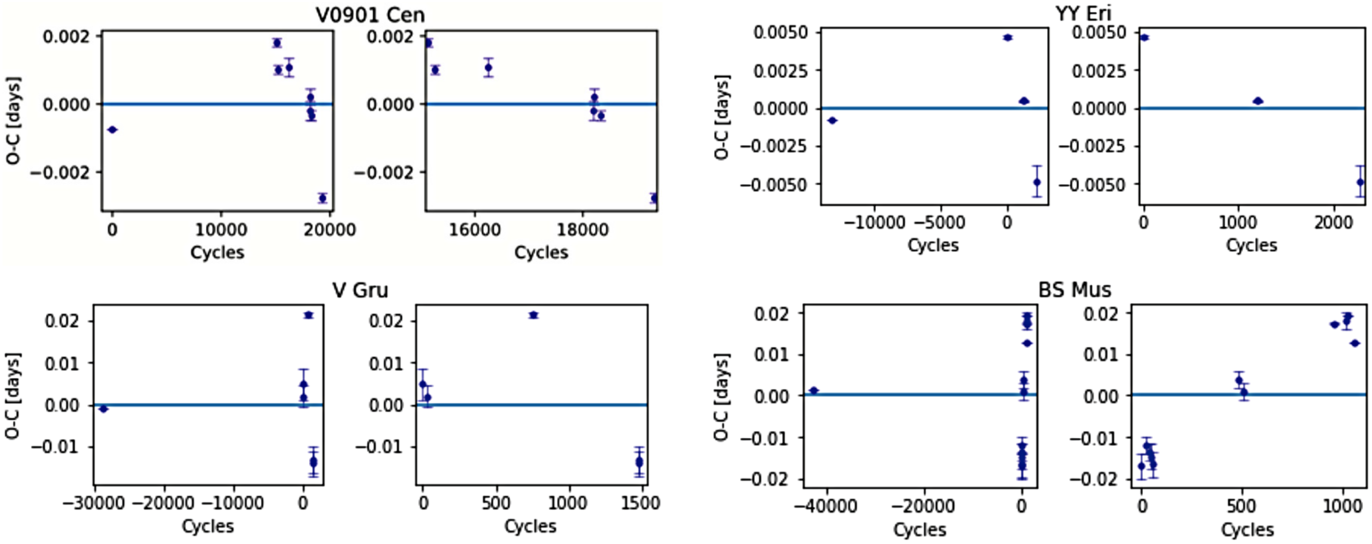

Figure 1. Residual (O–C) plots of the minima estimates against the light elements listed in Table 3. Left-hand panels for each binary system show VSX and VSS minima, right-hand panels the VSS minima only. Orbital cycle numbers count from zero at the first (regressed) VSS minimum, incrementing by the regressed period.

Regarding the data here for *V Gru*, it is diffficult to explain its O–C behavior. One possibility is an oscillating period.

BS Mus shows a very steep upward slope on the VSS data, and as with YY Eri an ephemeris based on VSS data could not accommodate the VSX data point. A cycle count jump is the likely explanation.

4. Conclusion

We have presented 246 minima estimates of 77 southern eclipsing binaries made by the authors in 2020. We have included a preliminary period analysis for four of them where we have acquired four or more minima in this year (2020) and earlier years, spread over at least three observing seasons. In none of these four cases is there a clear indication of a linear period, but nor can the type of any non-linear period (linear period change or period oscillation) be specified, let alone quantified. Because of that they are interesting candidates for further research into period behavior, which, in addition to future minima estimates, requires collation of online sources of photometric data to bridge the gap between early (discovery and VSX) data and the VSS data sets.

For a more extensive study of some of these systems, spectroscopic data are also needed. For example, the contact binary in V1084 Sco is likely a member of a quadruple system with a detached binary (Rucinski and Duerbeck 2006). Most contact and close binary systems may have tertiary or higher order components (Pribulla and Rucinski 2006). Period changes in close binary systems that are part of triple or multiple systems would be expected due to interactions of the various components. Among the binary systems we report on here, preliminary radial velocity analyses with the broadening function show that TY Cap, FQ CMa, and V Gru are triple systems and BS Mus and GZ Pup are triple or quadruple systems (Moriarty 2021).

5. Acknowledgements

This research has made much use of the International Variable Star Index (VSX) database, operated at AAVSO, Cambridge, Massachusetts, USA (Watson *et al.* 2006).

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Samus, N. N., Kazarovets, E. V., Durlevich, O. V., Kireeva, N. N., and Pastukhova, E. N. 2017, *Astron. Rep.*, **61**, 80, *General Catalogue of Variable Stars: Version GCVS 5.1* (http://www.sai.msu.su/gcvs/gcvs/index.htm).

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Appendix A: Minima Estimates

Identifier	*Type*	*HJD of Min.*	*Error*	*Min.*	*Filter*	*Obs.*
YY Aps	EB	2459009.18076	0.00303	P	SR	TR
NT Aps	EW	2459035.06790	0.00094	P	I	MB
NT Aps	EW	2459036.09990	0.00126	S	I	MB
NT Aps	EW	2459036.10054	0.00135	S	V	MB
NT Aps	EW	2459036.10064	0.00128	S	B	MB
NT Aps	EW	2459036.98395	0.00108	S	B	MB
NT Aps	EW	2459036.98436	0.00147	S	V	MB
NT Aps	EW	2459036.98495	0.00148	S	I	MB
NT Aps	EW	2459037.13033	0.00127	P	V	MB
NT Aps	EW	2459037.13057	0.00114	P	B	MB
NT Aps	EW	2459037.13105	0.00117	P	I	MB
V354 Aps	EA	2459039.01091	0.00180	P	SR	TR
DX Aqr	EA	2459128.05282	0.00169	P	V	MB
EE Aqr	EB	2459118.02437	0.00103	P	I	MB
EE Aqr	EB	2459132.02102	0.00241	S	I	MB
V610 Ara	EW	2459025.11863	0.00417	S	V	RA
V610 Ara	EW	2459025.93232	0.00238	P	V	RA
V610 Ara	EW	2459027.01624	0.00234	P	V	RA
V610 Ara	EW	2459032.99357	0.00316	P	B	RA
V610 Ara	EW	2459035.16639	0.00583	P	B	RA
V610 Ara	EW	2459037.06851	0.00347	S	B	RA
V870 Ara	EW	2459003.08566	0.00176	P	I	MB
V870 Ara	EW	2459016.07958	0.00228	S	V	MB
V870 Ara	EW	2459016.07983	0.00250	S	I	MB
V870 Ara	EW	2459016.08041	0.00235	S	B	MB
V870 Ara	EW	2459016.27892	0.00232	P	B	MB
V870 Ara	EW	2459016.27893	0.00231	P	V	MB
V870 Ara	EW	2459016.27916	0.00259	P	I	MB
X Cae	EC	2459164.99236	0.00369	P	I	MB
X Cae	EC	2459165.13360	0.00392	S	I	MB
TY Cap	EA/SD+DSCT	2459168.97490	0.00166	P	V	MB
ST Car	EB/SD	2458955.11084	0.00072	P	V	MB
BH Cen	EB/KE	2458929.01847	0.00081	S	B	MB
BH Cen	EB/KE	2458929.01874	0.00064	S	V	MB
BH Cen	EB/KE	2458929.01876	0.00112	S	I	MB
V676 Cen	EW/KW	2458986.08538	0.00044	S	SR	TR
V901 Cen	EW/RS	2458892.13909	0.00124	P	SR	TR
V901 Cen	EW/RS	2458897.09869	0.00135	P	SR	TR
V901 Cen	EW/RS	2458939.96070	0.00106	P	SR	TR
V901 Cen	EW/RS	2458940.13776	0.00110	S	SR	TR
WY Cet	EA/SD+DSCT	2459160.01400	0.00134	P	I	MB
DM Cir	EW	2458979.99346	0.00095	S	V	MB
DM Cir	EW	2458979.99355	0.00093	S	B	MB
DM Cir	EW	2458979.99383	0.00122	S	I	MB
DM Cir	EW	2458980.18764	0.00097	P	B	MB
DM Cir	EW	2458980.18776	0.00115	P	V	MB
DM Cir	EW	2458980.18783	0.00100	P	I	MB
DM Cir	EW	2458980.96012	0.00105	P	V	MB
DM Cir	EW	2458980.96085	0.00128	P	B	MB
DM Cir	EW	2458980.96121	0.00115	P	I	MB
DM Cir	EW	2458981.15462	0.00108	S	B	MB
DM Cir	EW	2458981.15470	0.00122	S	V	MB
DM Cir	EW	2458981.15541	0.00135	S	I	MB
FQ CMa	EA+DSCT	2458870.96372	0.00086	P	V	MB
FQ CMa	EA+DSCT	2458870.96388	0.00084	P	B	MB
FQ CMa	EA+DSCT	2458870.96388	0.00083	P	I	MB
FQ CMa	EA+DSCT	2458880.02359	0.00222	S	I	MB
FQ CMa	EA+DSCT	2458881.11035	0.00082	P	I	MB
FQ CMa	EA+DSCT	2458881.11036	0.00068	P	V	MB
FQ CMa	EA+DSCT	2458881.11038	0.00070	P	B	MB
eps CrA	EW	2459117.03715	0.00294	P	V	MB
eps CrA	EW	2459117.92324	0.00469	S	V	MB
RW Dor	EW:KW	2459187.06542	0.00055	S	SR	TR
AP Dor	EW	2459168.02296	0.00191	P	V	MB
YY Eri	EW/KW	2459191.95781	0.00097	P	I	MB
BV Eri	EW	2459137.05952	0.00178	S	I	MB
V Gru	EW/KW	2459078.02824	0.00154	S	V	MB
V Gru	EW/KW	2459078.02838	0.00163	S	B	MB
V Gru	EW/KW	2459078.02910	0.00148	S	I	MB
V Gru	EW/KW	2459078.26921	0.00295	P	I	MB
V Gru	EW/KW	2459078.27006	0.00309	P	V	MB
V Gru	EW/KW	2459090.11505	0.00104	S	V	MB
RV Gru	EW/EK	2459075.26875	0.00052	P	V	MB
RV Gru	EW/KW	2459090.97038	0.00089	S	SR	TR
RV Gru	EW/KW	2459091.10014	0.00060	P	SR	TR
RV Gru	EW/EK	2459168.05135	0.00057	S	V	MB
YY Gru	EW	2459107.00823	0.00065	S	SR	TR
YY Gru	EW	2459108.03245	0.00070	P	SR	TR
YY Gru	EW	2459108.17896	0.00066	S	SR	TR
BC Gru	EW:/KW:	2459083.04124	0.00409	S	V	RA
BC Gru	EW:/KW:	2459083.19399	0.00532	P	V	RA
BC Gru	EW:/KW:	2459085.03911	0.00270	P	V	RA
BC Gru	EW:/KW:	2459085.19249	0.00342	S	V	RA
BC Gru	EW:/KW:	2459085.96148	0.00317	P	V	RA
BC Gru	EW:/KW:	2459086.26803	0.00366	P	V	RA
BC Gru	EW:/KW:	2459087.03701	0.00240	S	V	RA
BC Gru	EW:/KW:	2459087.18929	0.00285	P	V	RA
DY Gru	EW/KW	2459092.05019	0.00094	S	V	MB
DY Gru	EW/KW	2459128.00538	0.00097	S	V	MB
DY Gru	EW/KW	2459136.91075	0.00094	P	V	MB
SZ Hor	EB	2459124.05406	0.00002	S	V	RJ
SZ Hor	EB	2459195.00065	0.00308	P	SR	TR
WZ Hor	EA	2459127.14875	0.00230	P	I	MB
WZ Hor	EA	2459132.97972	0.00211	P	V	MB
CP Hyi	EW	2459131.96725	0.00312	P	V	MB
CP Hyi	EW	2459136.99961	0.00264	S	V	MB
CN Ind	EW	2459061.02373	0.00538	S	V	RA
CN Ind	EW	2459061.25056	0.00639	P	V	RA
CN Ind	EW	2459062.15687	0.00343	P	V	RA
CN Ind	EW	2459066.23980	0.00619	P	B	RA
CN Ind	EW	2459066.92096	0.00543	S	B	RA
CN Ind	EW	2459067.14730	0.00402	P	B	RA
CN Ind	EW	2459078.94261	0.00231	P	V	RA
CN Ind	EW	2459079.16844	0.00425	S	V	RA
CN Ind	EW	2459080.98361	0.00467	S	V	RA
CN Ind	EW	2459081.21017	0.00435	P	V	RA
CO Ind	EB/KE	2458726.19515	0.00132	P	V	TR
CO Ind	EB/KE	2458744.13395	0.00120	P	SR	TR
CR Ind	EW	2458737.27507	0.00103	S	SR	TR
CR Ind	EW	2459121.05600	0.00093	S	SR	TR
CU Ind	EW	2459090.15378	0.00123	S	SI	TR
RR Lep	EB	2459192.04276	0.00167	P	V	MB
AU Men	EW	2459198.13718	0.00076	P	SR	TR
XY Men	EB/KE	2459192.05037	0.00013	P	V	RJ
XY Men	EB/KE	2459213.01845	0.00436	P	SR	TR
AH Mic	EW/KW	2459089.94253	0.00085	S	V	MB
AH Mic	EW/KW	2459090.10476	0.00094	P	V	MB
AH Mic	EW/KW	2459090.91573	0.00088	S	R	MB
AH Mic	EW/KW	2459091.07620	0.00115	P	R	MB
AH Mic	EW/KW	2459091.24165	0.00103	S	R	MB
AH Mic	EW/KW	2459108.91458	0.00112	P	I	MB
AH Mic	EW/KW	2459109.07917	0.00122	S	I	MB
TU Mus	EB/KE	2458986.09161	0.00009	S	V	RJ
TV Mus	EW/KW	2458948.11848	0.00229	S	SR	TR
TW Mus	EW/KW	2458920.04601	0.00155	P	SR	TR
TW Mus	EW/KW	2458920.25557	0.00132	S	SR	TR
DE Mic	EW	2459118.96789	0.00125	P	V	MB
DE Mic	EW	2459125.94931	0.00115	P	V	MB
BR Mus	EW/KE	2458985.97818	0.00123	P	SR	TR
BS Mus	EB/KE	2458924.10257	0.00009	P	V	RJ
BS Mus	EB/KE	2458939.09520	0.00004	S	V	RJ
BS Mus	EB/KE	2458967.12467	0.00207	P	SR	TR
BS Mus	EB/KE	2458974.04027	0.00018	P	V	RJ
BS Mus	EB/KE	2459003.99520	0.00008	P	V	RJ
V395 Nor	EW	2459017.13878	0.00144	P	V	MB
EI Oct	EW	2459063.96363	0.00067	P	V	MB

Table continued on next page

Appendix A: Minima Estimates (cont.)

Identifier	*Type*	*HJD of Min.*	*Error*	*Min.*	*Filter*	*Obs.*	*Identifier*	*Type*	*HJD of Min.*	*Error*	*Min.*	*Filter*	*Obs.*
EI Oct	EW	2459064.13377	0.00068	S	V	MB	V632 Sco	EA	2459066.04093	0.00170	P	B	MB
EI Oct	EW	2459078.01351	0.00116	S	I	MB	V638 Sco	EA/D:	2456114.10783	0.00300	P	V	DM
EI Oct	EW	2459078.01377	0.00081	S	V	MB	V638 Sco	EA/D:	2459002.98610	0.00300	P	B	DM
EI Oct	EW	2459078.01378	0.00122	S	B	MB	V638 Sco	EA/D:	2459007.70376	0.00200	P	B	PE
EI Oct	EW	2459078.18112	0.00093	P	I	MB	V638 Sco	EA/D:	2459014.77873	0.00200	P	B	PE
EI Oct	EW	2459078.18213	0.00108	P	B	MB	V638 Sco	EA/D:	2459036.00349	0.00210	P	V	MB
EI Oct	EW	2459078.18216	0.00106	P	V	MB	V638 Sco	EA/D:	2459036.00361	0.00240	P	I	MB
EI Oct	EW	2459085.96900	0.00074	P	B	MB	V638 Sco	EA/D:	2459036.00405	0.00238	P	B	MB
EI Oct	EW	2459086.13807	0.00074	S	B	MB	V701 Sco	EW/KE	2459032.12467	0.00264	S	V	MB
EI Oct	EW	2459088.00030	0.00060	P	I	MB	V701 Sco	EW/KE	2459032.12494	0.00344	S	I	MB
EI Oct	EW	2459088.16987	0.00070	S	I	MB	V701 Sco	EW/KE	2459062.97966	0.00336	P	I	MB
EZ Oct	EW/KW	2458883.05284	0.00006	S	V	RJ	V701 Sco	EW/KE	2459062.98109	0.00292	P	B	MB
EZ Oct	EW/KW	2458902.06385	0.00005	P	V	RJ	V701 Sco	EW/KE	2459062.98156	0.00293	P	V	MB
EZ Oct	EW/KW	2459017.98761	0.00096	S	SR	TR	V1055 Sco	EW	2459006.98131	0.00150	S	I	MB
EZ Oct	EW/KW	2459018.13052	0.00087	P	SR	TR	V1055 Sco	EW	2459007.16255	0.00158	P	I	MB
EZ Oct	EW/KW	2459018.27309	0.00073	S	SR	TR	V1055 Sco	EW	2459049.89707	0.00234	S	V	MB
EZ Oct	EW/KW	2459028.99389	0.00130	P	V	TR	V1055 Sco	EW	2459049.89727	0.00208	S	B	MB
EZ Oct	EW/KW	2459029.13698	0.00147	S	V	TR	V1055 Sco	EW	2459050.07873	0.00239	P	V	MB
BF Pav	EW	2459060.99834	0.00042	P	R	MB	V1055 Sco	EW	2459050.07908	0.00195	P	B	MB
HY Pav	EW/KW	2459063.01555	0.00061	S	V	MB	V1055 Sco	EW	2459050.98772	0.00166	S	B	MB
HY Pav	EW/KW	2459063.19024	0.00060	P	V	MB	V1055 Sco	EW	2459074.99078	0.00267	S	I	MB
HY Pav	EW/KW	2459109.96189	0.00091	P	B	MB	V1055 Sco	EW	2459074.99117	0.00257	S	B	MB
HY Pav	EW/KW	2459109.96224	0.00100	P	I	MB	V1055 Sco	EW	2459074.99128	0.00283	S	V	MB
HY Pav	EW/KW	2459110.13765	0.00120	S	I	MB	V1084 Sco	EW	2459064.02666	0.00165	P	V	MB
HY Pav	EW/KW	2459110.13820	0.00125	S	B	MB	QW Tel	EW	2459083.07234	0.00431	P	I	MB
V400 Pav	EB	2459067.11142	0.00265	P	V	MB	GN TrA	EA/KE	2459036.94501	0.00121	P	B	MB
V401 Pav	EW	2459045.00019	0.00087	P	SR	TR	GN TrA	EA/KE	2459036.94508	0.00137	P	I	MB
V401 Pav	EW	2459045.16291	0.00079	S	SR	TR	GN TrA	EA/KE	2459036.94556	0.00113	P	V	MB
YZ Phe	EW	2459162.05443	0.00075	P	V	TR	GQ TrA	EA+DSCT	2458973.06288	0.00455	S	I	MB
YZ Phe	EW	2459162.17327	0.00062	S	V	TR	GQ TrA	EA+DSCT	2458974.23171	0.00140	P	I	MB
AD Phe	EW/KW	2459141.01299	0.00007	P	V	RJ	GQ TrA	EA+DSCT	2459006.98418	0.00166	P	I	MB
AD Phe	EW/KW	2459167.98836	0.00006	P	V	RJ	V336 TrA	EW	2459001.07265	0.00068	P	B	MB
AD Phe	EW/KW	2459186.03242	0.00008	S	V	RJ	V336 TrA	EW	2459001.07268	0.00064	P	I	MB
AD Phe	EW/KE	2459186.98473	0.00004	P	V	RJ	V336 TrA	EW	2459001.07281	0.00048	P	V	MB
AU Phe	EW	2459171.08637	0.00083	S	SR	TR	V336 TrA	EW	2459008.94256	0.00089	S	B	MB
BQ Phe	EW	2459179.01475	0.00002	S	V	RJ	V336 TrA	EW	2459008.94256	0.00079	S	V	MB
GY Pup	EW/KW	2458874.03641	0.00141	P	SR	TR	V336 TrA	EW	2459008.94259	0.00084	S	I	MB
GZ Pup	EW/KW	2458850.04166	0.00082	S	V	TR	V336 TrA	EW	2459009.07572	0.00074	P	I	MB
GZ Pup	EW/KW	2458861.09059	0.00115	P	V	TR	V336 TrA	EW	2459009.07577	0.00063	P	B	MB
GZ Pup	EW/KW	2458879.02495	0.00127	P	V	TR	V336 TrA	EW	2459009.07580	0.00060	P	V	MB
GZ Pup	EW/KW	2458883.98942	0.00097	S	V	TR	V336 TrA	EW	2459016.01171	0.00071	P	I	MB
GZ Pup	EW/KW	2458884.14925	0.00104	P	V	TR	V336 TrA	EW	2459016.01174	0.00073	P	B	MB
GZ Pup	EW/KW	2459194.00698	0.00091	S	V	TR	V336 TrA	EW	2459016.01188	0.00058	P	V	MB
GZ Pup	EW/KW	2459194.16665	0.00101	P	V	TR	V336 TrA	EW	2459016.14512	0.00059	S	B	MB
HI Pup	EW/KW	2458851.06664	0.00143	S	SR	TR	V336 TrA	EW	2459016.14537	0.00066	S	V	MB
V653 Pup	EW	2458486.14701	0.00145	P	SR	TR	V336 TrA	EW	2459016.14543	0.00067	S	I	MB
RT Scl	EB	2459133.97002	0.00105	P	V	MB	AQ Tuc	EW	2458855.01766	0.00024	S	V	RJ
RT Scl	EB	2459136.01645	0.00105	P	V	MB	BU Vel	EW	2458919.03724	0.00191	S	SI	TR
UY Scl	EW	2459133.93005	0.00095	P	V	MB	DU Vel	EA	2458925.06656	0.00502	S	V	TR
UY Scl	EW	2459135.93265	0.00084	S	V	MB	FM Vel	EW/KW	2458896.02208	0.00102	S	SR	TR
UY Scl	EW	2459136.11661	0.00084	P	V	MB	FM Vel	EW/KW	2458896.21661	0.00109	P	SR	TR
BB Scl	EA	2459132.17127	0.00105	P	V	MB	FM Vel	EW/KW	2458917.05622	0.00096	S	SR	TR
V462 Sco	EW	2459050.00781	0.00134	P	R	MB	FM Vel	EW/KW	2458917.25124	0.00130	P	SR	TR
V632 Sco	EA	2459032.22726	0.00180	P	I	MB	V362 Vel	EW	2458952.13686	0.00235	P	I	MB
V632 Sco	EA	2459032.22767	0.00177	P	V	MB	W Vol	EA/AR	2458921.12717	0.00192	P	SR	TR

Observers: TR, T. Richards; RA, R. A. Axelsen; MB, M. Blackford; RJ, R. Jenkins; DM, D. J. W. Moriarty.