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CCD MINIMA FOR SELECTED ECLIPSING BINARIES IN 2022

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Abstract: A total of 150 CCD determinations of times of minimum for selected eclipsing binaries occurring in 2022 are presented. These were obtained at either Mountain Ash Observatory in Prince George, BC, Canada or Desert Blooms Observatory in Benson, AZ, USA.

1 Introduction

This is the 25th and final annual report of CCD eclipse minima timings by the lead author, as ill health will prevent further work. Here we present a total of 150 minima timings of eclipsing binaries acquired in the calendar year 2022.

2 Observations and Data Reduction

Selection of targets was made possible by the software *EB_Min* available at Nelson (2013). This software makes use of the data in *EB_Elements*5c_*A.xls* available at http://binaries.boulder.swri.edu/binaries/worksheets which lists parameters from some 10269 eclipsing systems (at last count) largely based on a database of over 5400 O-C files available at Nelson (2019) or http://binaries.boulder.swri.edu/binaries/omc/. *EB_Min* generates a customized nightly ephemeris taking into account the observer's local horizon and user-defined obstructions. Choices were made to maximize the scientific value of the timings based on inspections of the latest O-C files.

1. Observatory and Telescope:
   - Mountain Ash Observatory (MAO), 53°54'41.52" N, 122°47'23.82" W, elev 606 m.; 33 cm $f/4.5$ Newtonian on Paramount ME (German equatorial) mount
   - Desert Blooms Observatory (DBO), 31°56'27.96" N, 110°15'25.14" W, elev. 1095 m; 40 cm $f/6.8$ Meade SCT telescope on Paramount Taurus 400 (equatorial fork) mount
2. Detector and Filters (all provided a choice of B, V, R_c, I_c, clear filters):
   - MAO: SBIG ST-10XME camera, 2184 x 1472 pixels, each 6.8 μm, FOV 34.4' x 23.2'
   - DBO: QSI 683 camera, 3326 x 2504 pixels, each 5.4 μm (binned 2x2), FOV 22.3' x 16.8'

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3. Method of data reduction:
   - Differential aperture photometry using MIRA by Mirametrics Inc..
4. Method of minimum determination:
   - A choice of six methods as implemented in software *Minima* available at Nelson (2013). Among those used here are: digital tracing paper method, Kwee & van Woerden (1956), five-term Fourier fit, and sliding integrations.

3 Results

As mentioned above, up to four methods were used to extract times-of-minima from light curves surrounding each minimum. Every effort was made to include at least the inflection points in the light curve (and more if possible). This involved runs of typically three hours or more in duration, as shorter runs that capture only the bottom of the curve produce inaccurate results. For the data presented here, the assignment of errors took advantage of the fact that multiple determinations for each timing (i.e., by using the different algorithms) were available. The sample standard deviation of the values provides a starting point for the error estimate. However, it should be remembered that it represents only the statistical error, and it can be shown that the systematic error is at least as large. Therefore, for this observer, it is standard procedure to adopt double the sample standard deviation (or perhaps slightly larger) for the error estimate. At no time is an error of less than ±0.0001 day quoted.

Table 1 lists the minima estimates. Column 1 lists the GCVS star name (or if absent, the GSC name with the designation shortened to "G" to save space); column 2 lists the GCVS (or AAVSO-VSX) eclipsing type, columns 3 and 4 list the heliocentric minimum times and errors respectively; column 5 lists the minimum type (I signifies a primary minimum, while II signifies a secondary); column 6 lists the filter(s) used; column 7 lists the observatory, and the instruments used (see Section 2). In the case that multiple filters are listed (e.g., BVI_c), that signifies that the data were part of a full light curve acquisition; hence it would have been clearly seen whether the minimum was a primary or secondary one. In other cases, the assignment (of I or II) was based on the best available eclipse elements (epoch and period) and may or may not be correct. Again with the case of multiple filters listed, in almost all instances the differences in times between filters were deemed negligible and a single mean value was quoted. Lest there be a suggestion that all times of minima from the different filters should be listed separately, it is worthwhile pointing out the purpose of all these minimum determinations is to understand the period variation in each system. Multiple equal or near-equal values for the same minimum that one sees in the literature are basically a nuisance, as they do not further the understanding of period variation, and lead to longer tables with much duplication. Further, variations of minima between different filters will often be of interest only to observers gathering their own full light curve data, and they will have numerous examples of their own. Readers are encouraged to make use of the O-C databases at Nelson (2019) or http://binaries.boulder.swri.edu/binaries/omc/ which contains over 5400 Excel

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files for the latest elements, many of which will supercede those at AAVSO-VSX.

Table 1: Times-of-minima for eclipsing binaries in 2022

Star Name	GCVS Type	Time of Min. HJD-2400000	Error (days)	Ecl. Type	Filter used	Observatory
DS And	EB/DM	59609.6893	0.0004	I	B	DBO
V0440 And	EA	59850.7238	0.0001	I	c	MAO
V0829 Aql	EA/SD:	59711.9036	0.0005	I	c	DBO
ZZ Aur	EB/KE	59615.6822	0.0001	I	V	DBO
HL Aur	EB/SD	59660.6418	0.0003	I	V	DBO
V0599 Aur	EW	59626.6720	0.0010	II	V	DBO
AC Boo	EW/KW	59644.8344	0.0003	I	V	MAO
CK Boo	EW/KW	59693.8331	0.0003	I	B	DBO
FI Boo	EW	59681.7480	0.0006	I	c	MAO
GK Boo	EA	59657.9311	0.0003	I	BVI_c	DBO
GK Boo	EA	59717.8911	0.0003	II	BVI_c	DBO
GK Boo	EA	59721.7133	0.0002	II	BVI_c	DBO
GK Boo	EA	59725.7741	0.0004	I	BVI_c	DBO
GK Boo	EA	59727.6853	0.0003	I	BVI_c	DBO
GK Boo	EA	59729.8354	0.0004	II	BVI_c	DBO
GM Boo	EW	59682.8217	0.0003	I	c	MAO
GN Boo	EW	59625.9060	0.0002	II	c	MAO
IK Boo	EW	59667.7377	0.0002	I	c	MAO
SU Boo	EA/DM:	59699.8263	0.0004	I	c	DBO
TY Boo	EW/KW	59662.7997	0.0006	II	BVI_c	DBO
AK Cam	EA/SD:	59612.6448	0.0002	I	c	MAO
CV Cam	EB	59618.7180	0.0002	I	V	DBO
FN Cam	EW	59641.6885	0.0005	II	V	MAO
V0452 Cam	EW	59605.7881	0.0004	II	R_c	DBO
V0456 Cam	EW	59607.6097	0.0002	I	c	DBO
V0468 Cam	EW	59607.8762	0.0001	II	c	DBO
V0474 Cam	EW	59625.6768	0.0001	I	c	MAO
V0961 Cas	EB	59620.6132	0.0005	I	R_c	DBO
UZ CMi	EW/DW	59630.7362	0.0002	II	V	DBO
BF CMi	EA/SD:	59644.6540	0.0020	I	V	DBO
FW CMI	EB	59630.8284	0.0003	I	c	DBO
EH Cnc	EW	59635.6878	0.0001	I	c	MAO
ES Cnc	EA	59644.6970	0.0010	I	V	MAO
HN Cnc	EW	59601.7474	0.0002	I	R_c	DBO

IN Cnc	EB	59603.8287	0.0002	I	c	DBO
MU Cnc	EW	59589.8613	0.0002	II	V	DBO
NZ Cnc	EW	59615.7806	0.0002	II	c	DBO
NZ Cnc	EW	59632.8750	0.0002	II	V	DBO
OP Cnc	EW	59622.8449	0.0001	II	c	DBO
OX Cnc	EB / EW	59666.6920	0.0001	I	V	DBO
YY Cnc	EB	59701.6827	0.0005	I	c	DBO
CC Com	EW/KW	59647.7713	0.0001	I	c	MAO
LR Com	EA	59647.8514	0.0001	I	c	MAO
PU Com	EB/EW	59607.9822	0.0003	I	c	DBO
QS Com	EW	59624.8755	0.0003	II	V	DBO
SS Com	EW/KW	59636.7826	0.0003	II	c	DBO
AR CrB	EW	59658.8900	0.0005	I	c	MAO
AS CrB	EW	59690.7602	0.0002	I	c	MAO
AV CrB	EW	59662.8700	0.0001	II	c	MAO
AW CrB	EW	59633.0210	0.0010	II	c	DBO
CL CrB	EW	59640.9493	0.0005	I	c	DBO
YY CrB	EW	59605.9930	0.0001	II	V	MAO
BI CVn	EW/KW	59651.7722	0.0002	I	c	MAO
BO CVn	EW	59640.8185	0.0006	II	R_c	DBO
DF CVn	EW	59605.9357	0.0001	I	V	DBO
DH CVn	EW	59625.8031	0.0003	II	c	MAO
DL CVn	EB	59626.9351	0.0008	I	c	DBO
DX CVn	EW	59644.8235	0.0002	I	c	DBO
FV CVn	EW	59697.7681	0.0003	I	c	DBO
GN CVn	EW	59616.9172	0.0002	II	R_c	DBO
G3460-2083 CVn	EB/RS	59695.7060	0.0010	II	c	DBO
MR Cyg	EB/SD	59693.9695	0.0008	I	B	DBO
V0687 Cyg	EA/SD:	59697.8941	0.0001	I	V	DBO
V0836 Cyg	EB/KE	59810.7745	0.0002	I	V	MAO
V2846 Cyg	EW	59660.9902	0.0004	II	BVI_c	DBO
V2552 Cyg	EW/KW	59686.9431	0.0002	II	c	MAO
V2197 Cyg	EB	59804.7722	0.0005	II	c	MAO
BW Dra	EW/KW	59666.7950	0.0010	II	B	DBO
CV Dra	EW	59667.9307	0.0003	I	V	MAO
MY Dra	EA	59662.7357	0.0003	I	c	MAO
V0348 Dra	EW	59686.7566	0.0004	I	c	MAO
V0349 Dra	EW	59625.9953	0.0003	II	c	MAO
V0357 Dra	EW	59691.9028	0.0004	II	c	MAO
V0372 Dra	EB	59647.9664	0.0002	I	R_c	MAO

V0422 Dra	EB	59705.8586	0.0005	I	R_c	DBO
V0471 Dra	EW	59683.7279	0.0003	II	c	MAO
V0550 Dra	EW	59683.8477	0.0001	II	c	MAO
V0551 Dra	EW	59664.8758	0.0002	II	c	DBO
V0554 Dra	EW	59707.8156	0.0002	I	R_c	DBO
TYC 3539-1503-1 (Dra)	E	59669.9620	0.0050	I	BVI_c	DBO
TYC 3539-1503-1 (Dra)	E	59713.8134	0.0005	I	BVI_c	DBO
WW Gem	EB/KE	59636.6645	0.0002	I	B	DBO
V0405 Gem	EW	59583.8520	0.0020	II	B	DBO
V0482 Gem	EW	59583.7446	0.0002	I	B	DBO
V0857 Her	EW	59644.9360	0.0002	I	R_c	MAO
V1023 Her	EW	59636.8867	0.0005	I	R_c	DBO
V1038 Her	EW	59682.9375	0.0003	I	c	MAO
V1160 Her	EW	59630.9077	0.0003	II	c	DBO
V1181 Her	EW	59720.7988	0.0002	I	c	MAO
V1187 Her	EW	59628.9395	0.0005	II	c	DBO
V1306 Her	EW	59632.9758	0.0001	I	c	MAO
V1454 Her	EW	59667.8373	0.0006	II	c	MAO
V0474 Hya	EW	59626.8204	0.0004	II	V	DBO
V0572 Hya	EW	59657.6934	0.0003	I	R_c	DBO
V0647 Hya	EB	59622.7405	0.0005	I	c	DBO
CE Leo	EW/KW	59599.8692	0.0003	I	c	DBO
NZ Leo	EB / EW	59622.9418	0.0001	II	V	DBO
UX Leo	EA/SD:	59618.9363	0.0006	II	I	DBO
UX Leo	EB/SD	59660.7302	0.0005	I	BVI_c	DBO
UX Leo	EA/SD:	59669.7949	0.0005	I	BVI_c	DBO
XZ Leo	EB/KE	59656.7705	0.0004	II	R_c	MAO
XY LMi	EW	59605.8728	0.0001	II	c	MAO
AG LMi	EA	59632.7234	0.0003	I	R_c	MAO
HN Lyn	EW	59583.9909	0.0005	II	c	DBO
SW Lyn	EA/DW	59621.7100	0.0002	I	V	DBO
V0569 Lyr	EA	59719.8143	0.0004	I	c	MAO
V0592 Lyr	EW	59701.8321	0.0002	II	c	DBO
GU Mon	EW	59618.6194	0.0005	II	c	DBO
NS Mon	EW/DW	59607.7325	0.0001	I	V	DBO
V0864 Mon	EW	59601.8755	0.0002	I	B	DBO
V0927 Mon	EW	59581.7750	0.0010	I	V	DBO
V0958 Mon	EW/KW	59632.6361	0.0003	I	R_c	DBO
V1008 Mon	EW	59628.6238	0.0004	II	V	DBO
V0508 Oph	EW/KW	59683.9462	0.0003	II	c	MAO

V2713 Oph	EB	59703.8890	0.0003	I	c	DBO
V3687 Oph	EW	59715.8858	0.0004	II	V	DBO
V1848 Ori	EW	59600.6594	0.0001	I	c	MAO
V1853 Ori	EW	59630.6092	0.0003	II	V	DBO
V2788 Ori	EW	59640.6634	0.0004	I	V	DBO
V0404 Peg	EW	59797.8352	0.0003	II	c	MAO
V0560 Peg	EA/EB	59812.7798	0.0002	I	R	MAO
V0740 Per	EW	59624.6884	0.0002	I	c	DBO
V1092 Per	EW	59650.6300	0.0006	II	B	DBO
VZ Psc	EW/KW	59585.5929	0.0006	II	BVR_cI_c	DBO
AU Ser	EW/KW:	59717.7799	0.0003	I	R_c	MAO
CL Sex	EB / EW	59658.6594	0.0003	I	R_c	DBO
WY Sex	EW	59632.7462	0.0002	II	R_c	DBO
Y Sex	EW/KW	59654.6870	0.0010	I	B	DBO
RZ Tau	EW/DW	59599.7710	0.0020	I	V	DBO
V1128 Tau	EW	59622.6213	0.0004	I	B	DBO
V1377 Tau	EW	59597.6068	0.0002	II	V	DBO
CC Tri	EW	59601.6400	0.0002	I	c	DBO
AA UMa	EW/KW	59603.9255	0.0002	I	V	DBO
AA UMa	EW/KW	59650.7388	0.0001	I	R_c	DBO
HN UMa	EW:	59628.7188	0.0006	I	B	DBO
IW UMa	EA	59628.8376	0.0003	I	V	DBO
MQ UMa	EW	59705.7038	0.0004	II	c	DBO
UY UMa	EW/KW	59615.9020	0.0002	II	c	DBO
XY UMa	EB/DW/RS	59589.9579	0.0005	II	B	DBO
RU UMi	EB/DW	59658.7684	0.0003	II	c	MAO
TV UMi	EW	59632.8550	0.0050	I	V	MAO
AX Vir	EB/KE	59642.9041	0.0001	I	V	DBO
AZ Vir	EW/KW	59709.7050	0.0002	I	B	DBO
HW Vir	EA	59601.9703	0.0001	I	V	DBO
HW Vir	EA	59602.0287	0.0002	II	V	DBO
PU Vir	EW	59715.7241	0.0005	I	V	DBO
V0342 Vir	EA	59699.7024	0.0003	I	V	DBO
V0667 Vir	EW	59719.7488	0.0003	II	R_c	DBO
V0687 Vir	EA	59664.7669	0.0001	I	V	DBO
V0722 Vir	EA	59709.7050	0.0002	I	V	DBO

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References

Kreiner, J.M. 2004, *Acta Astron.*, **54**, 207

Kundera, T. 2012, Eclipsing Binaries Minima Database: http://www.oa.uj.edu.pl/ktt/krttk_dn.html

Kwee, K.K., & van Woerden, H. 1956, *Bull. Astr. Neth.*, **12**, 327

Nelson, R.H. 2013, *Software by Bob Nelson: https://www.variablestarssouth.org/resources/bob-nelsons-software-tools/software-by-bob-nelson*

Nelson, R.H. 2019, *AAVSO: Bob Nelson's Database of Eclipsing Binary O-C Files: https://www.aavso.org/bob-nelsons-o-c-files*

Paschke, A., & Brát, B.L. 2012, *O-C Gateway: http://var.astro.cz/ocgate/index.php?lang=en*