

# CCD MINIMA FOR SELECTED ECLIPSING BINARIES IN 2021

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**Abstract:** A total of 214 CCD determinations of times of minimum for selected eclipsing binaries occurring in 2021 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 24th annual report of CCD eclipse minima timings by this observer. Here we present a total of 214 minima timings of 195 eclipsing binaries acquired in the calendar year 2021.

## 2 Observations, Data Reduction and Analysis

Selection of targets was made possible by software *EB\_Min* (available at Nelson 2020a). This software makes use of the data in *EB\_Elements5c.xls* (also available at the same website) which lists parameters from some 8847 eclipsing systems (at last count) largely based on a database of some 5473 O-C files available at Nelson (2019, 2020b). *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.

- Observatory and Telescope:
  1. 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
  2. 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 (fork) mount
- Detector and Filters (all provided a choice of B, V, Rc, Ic, clear filters):
  1. mao: SBIG ST-10XME camera, 2184 x 1472 pixels, each 6.8 μm, FOV 34.4' x 23.2'
  2. DBO: QSI 683 camera, 3326 x 2504 pixels, each 5.4 μm (binned 2x2), FOV 22.3' x 16.8'
- Method of data reduction: Differential photometry using MIRA by Mirametrics Inc.
- Method of minimum determination: A choice of six methods as implemented in software *Minima* available at Nelson (2013, 2020a). Among those available, and used

here are: digital tracing paper method, Kwee and van Woerden (1956), five-term Fourier fit, and sliding integrations.

### 3 Data analysis

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  $\pm 0.0001$  day quoted.

### 4 Results

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 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 in data line 13), 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. In the case of one timing (KU Aur on 2021-01-31) the differences between filters were not negligible and separate eclipse times are quoted. (But for an earlier timing for the same star, the differences between filters *were* negligible.) 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.

Table 1: Times of minima of eclipsing binaries

Star Name	GCVS Type	Time of Min. HJD- 2400000	Error (days)	Eclipse Type	Filter used	Observed vatory
AP And	EA/DM	59447.7849	0.0002	I	V	mao
KP And	EA	59520.6457	0.0003	I	c	mao
QX And	EW	59510.6661	0.0006	I	c	mao
V0404 And	EA/RS	59397.8884	0.0003	I	c	mao
V0449 And	EW	59548.7316	0.0002	II	c	DBO
V0537 And	EA	59553.7902	0.0002	I	V	DBO
V0546 And	EW	59251.668	0.001	I	V	DBO
V0566 And	EW	59515.6254	0.0001	II	c	mao
V0736 And	EW	59513.8823	0.0002	II	V	DBO
V0343 Aql	EA/SD:	59358.9122	0.0002	I	R	mao
V1814 Aql	EA	59375.8872	0.0002	I	R	DBO
SS Ari	EW/KW	59502.8114	0.0003	II	I	DBO
SS Ari	EW/KW	59503.8252	0.0002	I	BVI	DBO
SS Ari	EW/KW	59506.8706	0.0004	II	BVI	DBO
BM Ari	EW	59528.6775	0.0002	I	V	DBO
BO Ari	EW	59520.7572	0.0001	II	R	mao
BO Ari	EW	59560.6902	0.0003	I	B	DBO
CX Ari	EB	59518.7463	0.0001	I	c	mao
AH Aur	EW/DW	59232.7511	0.0002	II	V	DBO
HP Aur	EA	59532.8112	0.0001	I	V	DBO
KU Aur	EA/SD	59216.7512	0.0002	I	BVI	DBO
KU Aur	EA/SD	59245.7811	0.0002	I	I	DBO
KU Aur	EA/SD	59245.7816	0.0002	I	V	DBO
KU Aur	EA/SD	59245.7819	0.0002	I	B	DBO
V0410 Aur	EW	59518.857	0.0004	II	R	mao
V0599 Aur	EW	59505.9115	0.0005	I	c	mao
V0640 Aur	EW	59235.6407	0.0001	II	c	mao
V0826 Aur	EW	59509.7811	0.0002	I	R	DBO
V0841 Aur	EW	59564.6906	0.0002	I	c	DBO
V0845 Aur	EB	59554.8058	0.0002	I	V	DBO
V0855 Aur	EW	59519.8502	0.0005	I	c	mao
TY Boo	EW/KW	59338.6775	0.0003	II	R	DBO
TZ Boo	EW/KW	59354.6488	0.0007	II	B	DBO
VW Boo	EW/KW	59347.662	0.0003	II	V	DBO
XY Boo	EW/KW	59339.74	0.0003	II	c	mao
AC Boo	EW/KW	59346.6611	0.0003	I	V	DBO
DN Boo	EW	59326.7182	0.0004	I	V	DBO
FI Boo	EW	59235.9871	0.0004	I	R	mao
WW Cam	EA/DM	59556.6899	0.0002	I	V	DBO
AK Cam	EA/SD:	59565.8833	0.0005	I	R	mao

AO Cam	EW/KW	59515.7755	0.0003	I	c	mao
CV Cam	EW/DW	59505.8194	0.0004	I	V	mao
LR Cam	EW	59528.7667	0.0001	I	V	DBO
OP Cam	EW	59519.8029	0.0003	II	c	DBO
OQ Cam	EW	59524.9181	0.0001	II	V	DBO
V0366 Cam	EW	59535.7918	0.0007	II	c	mao
V0403 Cam	EW	59553.8192	0.0004	I	c	mao
V0405 Cam	EW	59226.5839	0.0003	II	c	mao
V0455 Cam	EA	59226.7041	0.0003	I	c	mao
AB Cas	EA+dSct	59573.6358	0.0002	I	c	DBO
V0375 Cas	EB/KE	59438.8836	0.0009	II	R	mao
V0381 Cas	EA/DM	59566.631	0.001	I	V	DBO
V0537 Cas	EA	59546.8081	0.0002	II	R	DBO
V1337 Cas	EW	59546.7238	0.0003	II	B	DBO
VZ Cep	EA	59392.89	0.0003	I	V	mao
WZ Cep	EW/KW	59364.9323	0.0002	I	R	DBO
BE Cep	EW/KW	59401.8945	0.0001	I	c	mao
EG Cep	EB	59402.7792	0.0003	II	R	mao
V0870 Cep	EW	59401.8206	0.0003	II	c	mao
V0930 Cep	EW	59400.8689	0.0003	I	c	mao
V1019 Cep	EW	59535.6455	0.0003	II	c	mao
EE Cet	EW	59565.616	0.0003	II	V	mao
IP Cet	EW	59515.807	0.0004	I	c	DBO
KO Cet	EB	59538.7255	0.0002	II	V	DBO
UZ CMi	EW/DW	59554.9232	0.0002	I	V	DBO
FM CMi	EB	59328.6681	0.0004	II	V	DBO
TX Cnc	EW/KW	59528.9959	0.0004	I	V	DBO
GW Cnc	EW	59560.8932	0.0002	II	c	DBO
IT Cnc	EW:	59557.0012	0.0005	I	c	DBO
NV Cnc	EA/SD	59257.6948	0.0003	II	c	mao
OW Cnc	EW	59259.7096	0.0003	II	c	mao
RW Com	EW/KW	59553.9859	0.0003	II	c	DBO
RZ Com	EW/KW	59257.8119	0.0001	II	c	mao
QS Com	EW	59228.6028	0.0001	II	c	mao
AR CrB	EW	59351.9368	0.0002	II	V	DBO
AW CrB	EW	59352.9386	0.0005	II	c	DBO
DR CVn	EW	59351.746	0.003	I	BVI	DBO
DR CVn	EW	59352.734	0.001	I	BVRI	DBO
DR CVn	EW	59362.7744	0.0008	II	BVRI	DBO
WZ Cyg	EB	59395.7798	0.0002	I	R	mao
CG Cyg	EA/SD/RS	59393.8738	0.0002	I	R	mao
V0401 Cyg	EW/KE	59355.8757	0.0001	I	c	mao
V0456 Cyg	EA/SD:	59363.8711	0.0001	I	R	mao
V0700 Cyg	EW/DW	59391.8449	0.0004	I	c	mao

V1815 Cyg	EW	59402.9009	0.0003	II	V	mao
V1918 Cyg	EW/KW	59387.717	0.001	II	V	DBO
V2545 Cyg	EW	59500.6368	0.0002	II	R	DBO
V2552 Cyg	EW/KW	59364.8438	0.0004	I	V	DBO
V2880 Cyg	EB	59515.664	0.001	I	BVI	DBO
G2703-1235 Cyg	EW	59398.8442	0.0002	I	c	mao
RZ Dra	EB/SD:	59371.8308	0.0002	I	R	mao
AX Dra	EB	59379.6746	0.0002	I	V	DBO
DD Dra	EA	59354.859	0.001	I	V	DBO
EF Dra	EW	59334.9029	0.0002	I	c	mao
FU Dra	EW	59257.9306	0.0002	II	c	mao
FU Dra	EW	59258.0836	0.0002	I	c	mao
V0348 Dra	EW	59345.7596	0.0005	I	c	mao
V0374 Dra	EW	59354.7886	0.0003	II	V	mao
V0450 Dra	EW	59235.85	0.0002	I	V	mao
V0527 Dra	EA	59354.8866	0.0001	I	c	mao
V0548 Dra	EW	59234.9989	0.0003	I	R	mao
V0550 Dra	EW	59362.9079	0.0003	I	B	DBO
V0564 Dra	EB	59373.8349	0.0003	II	R	DBO
G4019-2744 Dra	EW	59536.76	0.001	II	BVI	DBO
V0437 Gem	EW	59547.8304	0.0001	I	c	mao
V0443 Gem	EW	59577.7937	0.0002	II	c	mao
V0481 Gem	EW	59230.71	0.0001	I	c	mao
V0486 Gem	EW	59553.9011	0.0003	I	B	DBO
V0521 Gem	EB/EW	59517.9302	0.0002	I	c	mao
TU Her	EA/SD	59324.8986	0.0002	I	BVI	DBO
TX Her	EA	59344.825	0.001	II	BVI	DBO
TX Her	EA	59347.9134	0.0005	I	B	DBO
TX Her	EA	59349.9743	0.0005	I	BVI	DBO
CT Her	EA/SD	59348.8078	0.0002	I	BVI	DBO
V0728 Her	EW/KW	59339.8874	0.0002	II	c	mao
V0878 Her	EB	59363.7563	0.0003	I	R	mao
V1033 Her	EW	59326.9287	0.0003	II	BVI	DBO
V1033 Her	EW	59328.8672	0.0002	0	BVI	DBO
V1033 Her	EW	59334.8282	0.0004	I	BVI	DBO
V1033 Her	EW	59334.9766	0.0012	II	BVI	DBO
V1033 Her	EW	59338.8514	0.0003	II	BVI	DBO
V1033 Her	EW	59340.7893	0.0002	I	BVI	DBO
V1033 Her	EW	59340.9377	0.0004	II	BVI	DBO
V1033 Her	EW	59342.8757	0.0004	I	BVI	DBO
V1103 Her	EW	59354.9417	0.0005	II	c	DBO
V1167 Her	EW?	59357.7554	0.0003	I	R	mao
V1181 Her	EW	59377.863	0.001	II	R	DBO

V1187 Her	EW	59366.8131	0.0006	I	V	DBO
V1402 Her	EA	59356.8031	0.0003	I	c	mao
G2058-0753 Her	EW	59375.7415	0.0004	I	R	DBO
SW Lac	EW/DW	59438.7852	0.0002	II	V	mao
VX Lac	EA/SD	59397.8243	0.0001	I	c	mao
CO Lac	EA/DM	59386.8384	0.0002	I	R	mao
V0505 Lac	EW	59439.829	0.0001	I	R	mao
V0882 Lac	EW	59459.809	0.002	II	c	mao
UV Leo	EA/DW	59234.912	0.0001	I	V	mao
GU Leo	EW	59344.632	0.002	II	c	DBO
MO Leo	EW?	59230.837	0.002	II	c	mao
NR Leo	EB	59568.9616	0.0005	II	R	DBO
PT Leo	EW	59253.7577	0.0002	I	c	mao
RT LMi	EW/KW	59519.9815	0.0002	I	c	mao
RZ Lyn	EB/KE	59258.754	0.001	II	c	mao
CW Lyn	EB:	59220.9414	0.0008	I	BVI	DBO
DE Lyn	EW	59578.8607	0.0001	I	c	DBO
FI Lyn	EW	59254.7339	0.0003	II	c	mao
FN Lyn	EA	59544.9256	0.0005	I	V	DBO
FO Lyn	EW	59255.7655	0.0001	I	c	mao
HN Lyn	EW	59235.7298	0.0003	I	c	mao
KO Lyn	EW	59518.9718	0.0002	II	R	mao
V0653 Lyr	EW	59379.8563	0.0004	I	R	DBO
BM Mon	EA/SD	59548.8455	0.0001	I	c	DBO
V0448 Mon	EB/KE	59538.8831	0.0003	II	V	DBO
V0453 Mon	EW	59564.8076	0.0002	II	V	DBO
V0515 Mon	EA	59548.9375	0.0001	I	c	DBO
V0927 Mon	EW	59519.8947	0.0004	I	c	DBO
V1008 Mon	EW	59560.787	0.0003	I	R	DBO
V1014 Mon	EA	59532.9416	0.0003	I	B	DBO
V2701 Oph	EW	59373.9156	0.0002	II?	R	DBO
V3684 Oph	EW	59371.8455	0.0003	I	R	DBO
ER Ori	EW/KW	59224.7144	0.0004	I	V	DBO
ET Ori	EA/SD	59218.6384	0.0003	I	BVI	DBO
V0343 Ori	EW/DW	59556.8822	0.0004	II	V	DBO
V1848 Ori	EW	59550.8521	0.0002	I	V	DBO
V2759 Ori	EB	59546.9085	0.0008	I	B	DBO
V2787 Ori	EB	59228.7267	0.0004	I	c	mao
V2788 Ori	EW	59515.9042	0.0003	I	V	DBO
V2822 Ori	EW	59578.7587	0.0002	II	V	DBO
V0404 Peg	EW	59395.851	0.001	II	R	mao
V0481 Peg	EW	59407.8898	0.0004	II	R	mao
KW Per	EB/SD	59517.6306	0.0005	II	c	mao
V0432 Per	EW/DW	59547.7367	0.0002	II	c	mao

V0740 Per	EA/DM	59556.7949	0.0001	I	R	DBO
V0873 Per	EW	59547.6409	0.0004	I	c	mao
V0881 Per	EW/KW	59524.8199	0.0003	I	c	DBO
V0882 Per	EA	59510.7855	0.0002	I	c	mao
V1092 Per	EW	59553.7309	0.0003	I	V	mao
V1107 Per	EA	59541.767	0.002	I	c	mao
VZ Psc	EA/DM	59568.61	0.001	II	BVRI	DBO
DS Psc	EW	59530.7267	0.0002	II	V	DBO
DZ Psc	EW	59541.6467	0.0002	I	c	mao
GW Psc	EW	59538.604	0.002	II	c	DBO
HO Psc	EW	59528.8727	0.0002	I	V	DBO
AQ Ser	EB/DM	59355.7697	0.0006	II	c	mao
WY Sex	EW	59324.681	0.0003	II	V	DBO
CZ Sex	EB/EW	59334.6526	0.0005	I	R	DBO
DE Sex	EW	59549.0131	0.0001	II	c	DBO
CR Tau	EA	59568.845	0.0002	I	c	DBO
EQ Tau	EW/DW	59228.6048	0.0002	II	c	mao
V0781 Tau	EW/DW	59511.9195	0.0001	II	c	mao
V0781 Tau	EW/DW	59565.7255	0.0003	II	V	mao
V1121 Tau	EB:	59526.8263	0.0005	I	V	DBO
V1238 Tau	EW	59513.9878	0.0003	I	B	DBO
V1370 Tau	EW/KW	59552.7754	0.0005	I	V	mao
RS Tri	EA/DM	59518.903	0.0004	0	BVRI	DBO
CL Tri	EA	59554.6933	0.0002	I	R	DBO
DF Tri	EW	59550.7368	0.0002	I	c	DBO
TY UMa	EW/KW	59561.0345	0.0003	II	V	DBO
XY UMa	EB/DW/RS	59222.8041	0.0003	I	V	mao
ZZ UMa	EA/D	59256.7816	0.0007	I	c	mao
AA UMa	EW/KW	59536.9824	0.0002	I	V	DBO
ES UMa	EW	59234.7815	0.0006	I	c	mao
HH UMa	EW	59564.904	0.002	II	V	DBO
II UMa	EW	59577.9269	0.0002	I	c	mao
LP UMa	EW/KW	59553.9347	0.0003	I	c	mao
MT UMa	EW	59373.724	0.001	II	R	DBO
V0377 UMa	EW	58388.9965	0.0002	I	c	DBO
RU UMi	EB/DW	59255.8889	0.0002	I	c	mao
TV UMi	EW?	59253.8699	0.0006	I	V	mao
AH Vir	EW/KW	59350.7108	0.0005	II	BVRI	DBO
PS Vir	EW	59342.677	0.0003	II	c	DBO
V0631 Vir	EW	59371.736	0.0003	I	V	DBO
V0665 Vir	EW	59354.7489	0.0003	I	V	DBO
V0473 Vul	EB	59394.8387	0.0005	I	c	mao
V0496 Vul	EW	59393.8082	0.0002	I	c	mao

Readers are encouraged to make use of the O-C database at Nelson (2019, 2020b) which contains over 5400 Excel files for the latest elements, many of which will supersede those at VSX. Efforts are planned to reconcile any differences in elements between the two databases.

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