Period Study and Analysis of 2017 BVR$_c$I$_c$ Observations of the Totally Eclipsing, Solar Type Binary, MT Camelopardalis

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Abstract We report here on a period study and analysis of 2017 BVR$_c$I$_c$ light curves of MT Camelopardalis (GSC03737-01085). It is a solar type (T ~ 5500 K) eclipsing binary. It was observed for six nights in December 2017 at Dark Sky Observatory (DSO) with the 0.81-m reflector. Five times of minimum light were calculated from Terrell, Gross, and Cooney's (2016, *IBVS* 6166) 2004 and 2016 observations (hereafter TGC). In addition, eleven more times were taken from the literature and six determined from the present observations. From these 15 years of observations a quadratic ephemeris was calculated:

$$\text{JD Hel Min I} = \underset{\pm 0.00051}{2458103.66121\,\text{d}} + \underset{\pm 0.00000021}{0.36613905} \times E - \underset{\pm 0.000000000015}{0.000000000035} \times E2 \qquad (2)$$

A BVR$_c$I$_c$ filtered simultaneous Wilson-Devinney Program (WD) solution gives a mass ratio (0.3385 ± 0.0014), very nearly the same as TGC's (0.347 ± 0.003), and a component temperature difference of only ~140 K. As with TGC, no spot was needed in the modeling. Our modeling (beginning with BINARY MAKER 3.0 fits) was done without prior knowledge of TGC's. This shows the agreement achieved when independent analyses are done with the Wilson code. The present observations were taken 1.8 years later than the last curves by TGC, so some variation is expected.

The Roche Lobe fill-out of the binary is ~ 13% and the inclination is ~ 83.5 degrees. The system is a shallow contact W-type W UMa binary, albeit the amplitudes of the primary and secondary eclipse are very nearly identical. An eclipse duration of ~ 21 minutes was determined for the secondary eclipse and the light curve solution.

1. Introduction

Period studies are very important in characterizing the nature of orbital evolution of eclipsing binaries. Linear results imply that the period has been constant during the interval of observation of the binary. This gives a constant slope, O–C plot with random scatter about a horizontal line. Sudden period changes are marked by the sudden changes in slope in the plot of residuals. A quadratic result shows that the period is constantly changing—if it has a negative term, the period is decreasing. This may be due to a mass transfer so the mass ratio is approaching unity when the mass transfer is conservative. Otherwise (positive quadratic term), the mass ratio is tending to extreme values away from one. Negative quadratic terms can also be reflecting the case of angular momentum loss such as magnetic braking. Sinusoidal period changes result from light time effects due to the presence of a third body orbiting the system. In this study we find quadratic residuals. Short term quadratic changes can be a part of longer term sinusoidal curves.

2. History and observations

The variable was discovered by Nakajima *et al.* (2005) in the MISAO project as MisV1226, and identified as a W UMa binary with a period of 0.3662 day, with a magnitude range of V = 12.93–13.54. The discovery light curve is shown in Figure 1. The binary was named MT Cam in the "78th Name List" (Kazarovets *et al.* 2006).

The system was observed at two epochs, partially in 2004 in V, and with BVI$_c$ filters on 11, 13, and 14 February 2016 by Terrell, Gross, and Cooney (2016; hereafter TGC). Their light curve analysis found component ΔT ~ 150 K, inclination = 82°,

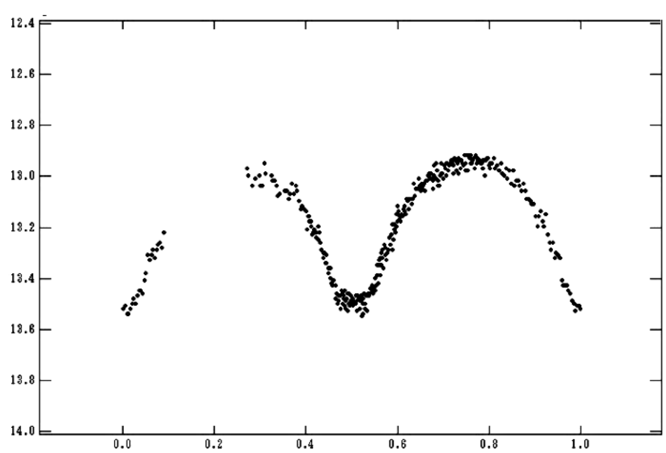

Figure 1. Light curve of Nakajima *et al.* (2005).

mass ratio, m_2/m_1 or $q=2.88$ ($1/q=0.35$), period $=0.366136$ d, and $dP/dt=1.6\times10^{-9}$. Their values yield a fill-out $=7.6$%. Their curves are displayed in Figure 2.

They assumed a T = 5368 K for the main component using APASS standards. Further, times of minimum light were published (Diethelm 2007, 2009, 2011, 2013; Nelson 2008).

This system was observed as a part of our professional collaborative studies of interacting binaries at Pisgah Astronomical Research Institute from data taken from Dark Sky Observatory (DSO) observations. The observations were taken by D. B. Caton. Reduction and analyses were done by Ron Samec. Our 2017 BVR_cI_c (Johnson-Cousins photometry) light curves were taken at DSO, in remote mode, with the 0.81-m DSO reflector on 5, 14, 15, 16, 17 December 2017 with a thermoelectrically cooled (–38° C) 1K × 1K FLI camera and Bessel BVR_cI_c filters.

Individual observations included 495 in B, 491 in V, 485 in R_c, and 491 in I_c. The probable error of a single observation was 10 mmag in B and V, 13 in R_c, and 11 mmag in I_c. The nightly C-K (Comparison-Check) star values stayed constant throughout the observing run with a precision of less than 1%. Exposure times varied from 60–100 s in B, 20–40 s in V, and 10–20 s in R_c and I_c. To produce these images, nightly images were calibrated with 25 bias frames, at least five flat frames in each filter, and ten 350-second dark frames. The BVR_cI_c observations are given in Table 1 as HJD vs Magnitude. Figures 3a and 3b show two sample B and V light curves taken 15 and 17 December 2017.

3. Finding chart

The finding chart, given here for future observers, is shown as Figure 4. The coordinates and magnitudes of the variable star, comparison star, and check star are given in Table 2.

4. Period study

Six mean times (from BVR_cI_c data averages) of minimum light were calculated from our present observations, four primary and two secondary eclipses. A least squares minimization

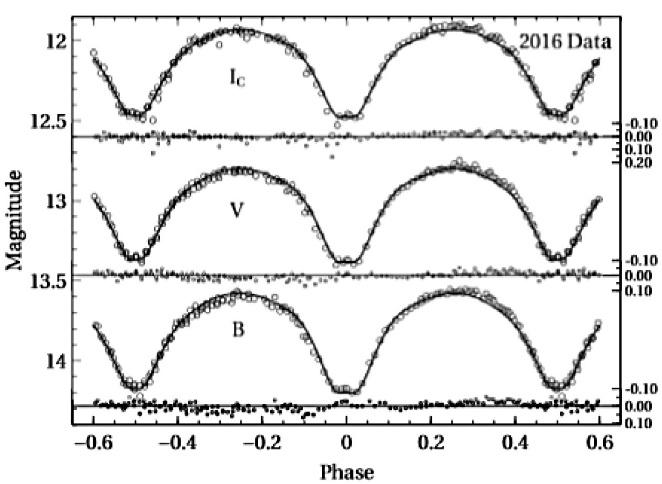

Figure 2. Observations by TGC.

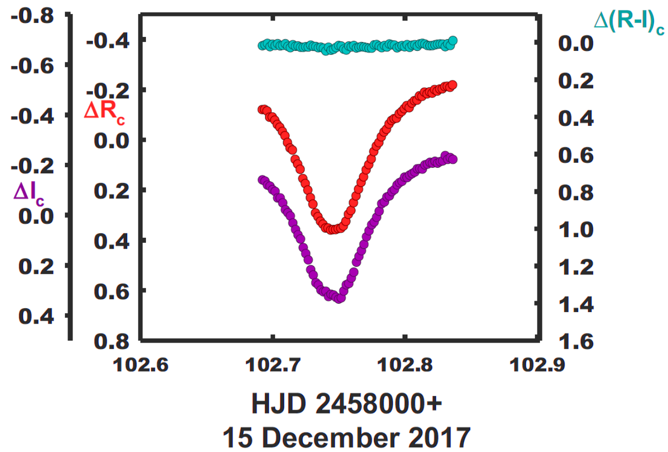

Figure 3a. Observations taken 15 December 2017. The errors for a single observation are given in section 2.

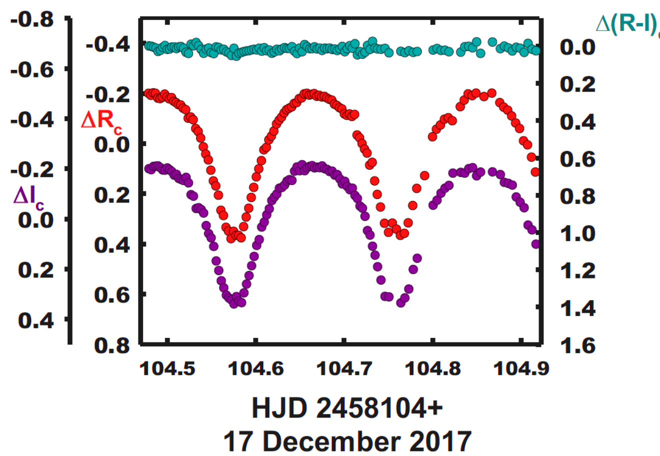

Figure 3b. Observations taken 17 December 2017. The errors for a single observation are given in section 2.

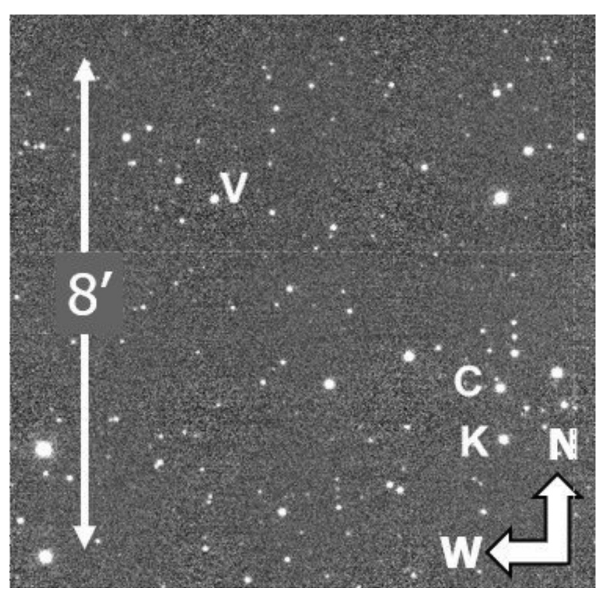

Figure 4. Finding Chart, MT Cam (V), Comparison Star (C), and Check Star (K).

method (Mikulášek *et al.* 2014) was used to determine the minima for each curve, in B,V,R_c, and I_c. These were averaged and the standard errors were determined. These are:

HJD Min I = 2458092.49374 ± 0.0002, 2458102.74600 ± 0.00007, 2458104.57686 ± 0.0002, 2458104.9434 ± 0.0029

HJD Min II = 2458103.6610 ± 0.0001, 2458104.7607 ± 0.0020.

All were weighted as 1.0 in the period study. The 2004 data (TGC) were analyzed to produce two more timings in V: HJD Min I = 2453320.7834, 2453330.6689 using the same method.

Three times of minimum light were calculated from 2016 BVI data (TGC):

HJD Min II = 2457429.7810 ±0.0005, 2457431.6126 ±0.0004, 2457432.7108 ±0.0006.

And finally, three more timings were calculated from data by Nakajima *et al.* (2005):

HJD Min I = 2452965.98833, 2452965.25301
HJD Min II = 2452975.32571

all with the same method.

These are single curves so no averaging was done and no errors are given.

Linear and quadratic ephemerides were determined from these data:

$$\text{JD Hel Min I} = 2458103.6617 + 0.366139551\,\mathrm{d} \times E \qquad (1)$$
$$\pm 0.0007 \pm 0.000000078$$

$$\text{JD Hel Min I} = 2458103.66121\,\mathrm{d} + 0.36613905 \times E - 0.000000000035 \times E^2 \qquad (2)$$
$$\pm 0.00076 \quad \pm 0.00000032 \quad \pm 0.000000000022$$

The r.m.s. of the residuals for the linear and the quadratic ephemerides are given in Table 3 to for comparison. The value for the quadratic calculation is somewhat smaller. This period study covers a period of over 15 years and shows (marginally) an orbital period that is decreasing (at the 1.5 sigma level). These ephemerides were calculated by a least square O–C program. If this is a true effect, it could be due to magnetic braking that occurs as plasmas leave the system on stiff, but rotating dipole magnetic field lines. This causes angular momentum loss. This scenario is typical for overcontact binaries which eventually may coalesce due to magnetic braking, albeit in a catastrophic way producing red novae (Tylenda and Kamiński 2016). The residuals from the quadratic equation (Equation 2) are shown in Figure 5. The linear and quadratic residuals of this study are given in Table 2. The quadratic ephemeris yields a period change, $\dot{P} = 9.18 \times 10^{-8}\,\mathrm{d/yr}$ or a mass exchange rate of

$$\frac{dM}{dt} = \frac{\dot{P} M_1 M_2}{3P\,(M_1 - M_2)} = \frac{-3.5 \times 10^{-8}\,\mathrm{M}_\odot}{\mathrm{d}} \qquad (3)$$

(Qian and Zhu 2002) in a conservative scenario.

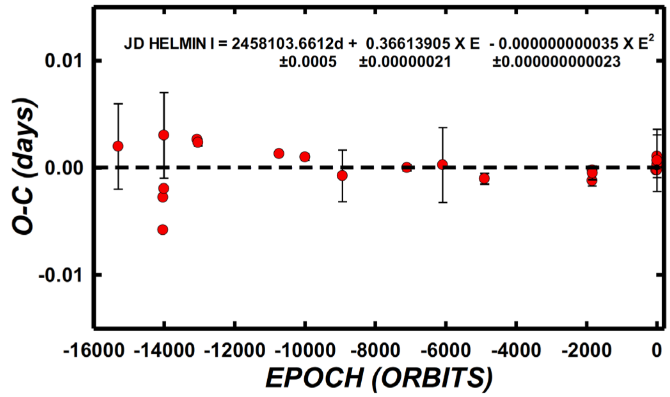

Figure 5. The Residuals from quadratic term in the period study of MT Cam. Error bars were not used as a weight for the determination of the best-fit of the quadratic ephemerides.

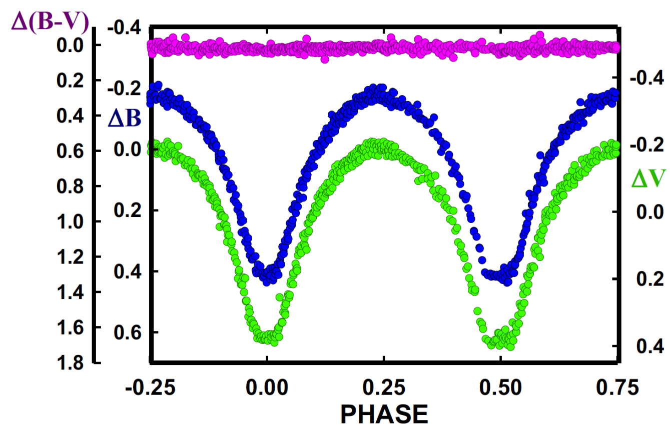

Figure 6a. B, V magnitude light curves of MT Cam phased by Equation 2.

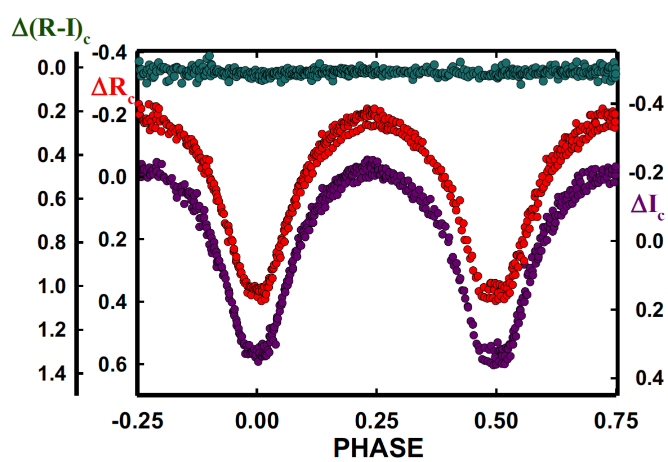

Figure 6b. R_c, I_c magnitude light curves of MT Cam phased by Equation 2.

5. Light curve characteristics

Light curve characteristics at quadratures are shown in Figures 6a, 6b, and Table 3. The curves are of good precision, averaging about 1% photometric precision. The amplitude of the light curve varies from 0.62 to 0.55 mag in B to I. The O'Connell effect (O'Connell 1951), an indicator of spot activity, averages larger than noise level, 0.02–0.04 mag, indicating magnetic spots. The differences in minima are miniscule, averaging 0.00 mag, indicating overcontact light curves in thermal contact. A time of constant light appears to occur at minima and lasts some 21 minutes as measured by the light curve solution about phase 0.5.

6. Temperature

The 2MASS J-K for the variable corresponds to a ~G7V spectral type which yields a temperature of 5500 ± 150 K (Houdashelt *et al.* 2000; Cox 2000). This value overlaps that of TGC. This temperature was used for the light curve analysis which was done without knowledge of the TGC analysis. Fast rotating binary stars of this type are noted for having convective atmospheres, so spots are expected, but in this case were not needed in modeling.

7. Light curve solution

The B, V, R_c, I_c curves were pre-modeled with BINARY MAKER 3.0 (Bradstreet and Steelman 2002) and fits were determined and averaged from all filter bands (q ~ 0.335, fill-out ~ 10%, ΔT ~ 150 K, i ~ 83°). The Wilson-Devinney solution (WD; Wilson and Devinney 1971; Wilson 1990, 1994; Van Hamme and Wilson 1998) was that of an overcontact eclipsing binary. The parameters were then averaged and input into a four-color simultaneous light curve calculation using WD. The solution was computed in Mode 3 (Wilson 2007) and converged to a solution. Convective parameters g = 0.32, A = 0.5 (Lucy 1967) were used. An eclipse duration of ~21 minutes was determined for the secondary eclipse (about phase 0.5) and the light curve solution. Thus, the binary is a W-type, W UMa binary. Since the eclipses were total, the mass ratio, q, is well determined with a fill-out of 13%. The light curve solution is given in Table 4. The Roche Lobe representation at quarter orbital phases is shown in Figures 7a, b, c, d, and the normalized fluxes overlaid by our solution of MT Cam in B, V, R_c, I_c are shown in Figures 8a and b.

8. Discussion

MT Cam is a shallow overcontact W UMa in a W-type configuration (T2 > T1). The system has a mass ratio of ~0.34, and a component temperature difference of only ~150 K. No spots were needed in the light curve modeling of the system. The Roche Lobe fill-out of the binary is ~13% with a high inclination of ~83.5° degrees. Fill-out is defined as:

$$\text{fill-out} = \frac{(\Omega_1 - \Omega_{ph})}{(\Omega_1 - \Omega_2)}, \tag{4}$$

where Ω_1 is the inner critical potential where the Roche Lobe surfaces reach contact at L_1, and Ω_2 is the outer critical potential where the surface reaches L_2.

Its spectral type indicates a surface temperature of 5500 K (Cox 2000) for the primary component, making it a solar type binary. Such a main sequence star would have a mass of 0.82 $M_\odot$ (Cox 2000) and, from the mass ratio, the secondary (from the mass ratio) would have a mass of 0.27 $M_\odot$, making it very much

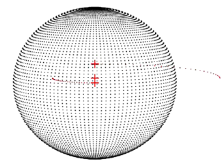

Figure 7a. MT Cam, geometrical representation at phase 0.00.

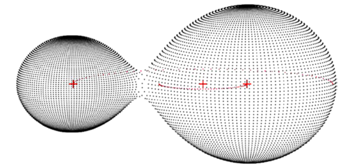

Figure 7b. MT Cam, geometrical representation at phase 0.25.

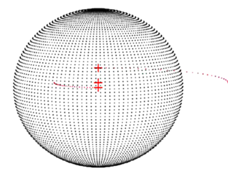

Figure 7c. MT Cam, geometrical representation at phase 0.50.

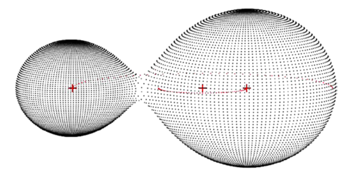

Figure 7d. MT Cam, geometrical representation at phase 0.75.

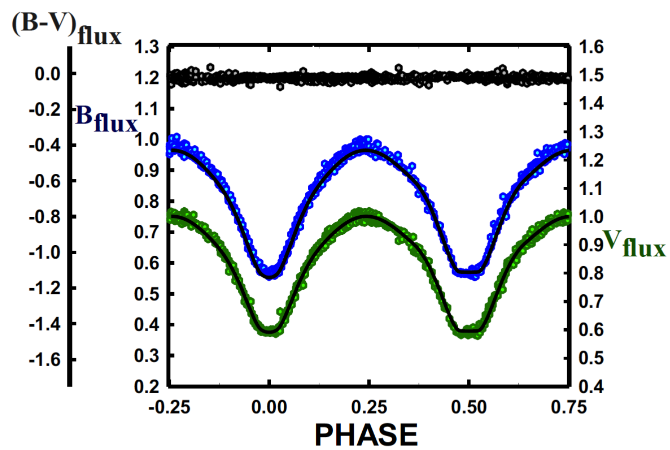

Figure 8a. MT Cam, B,V, and B–V normalized fluxes overlaid by the light curve solution.

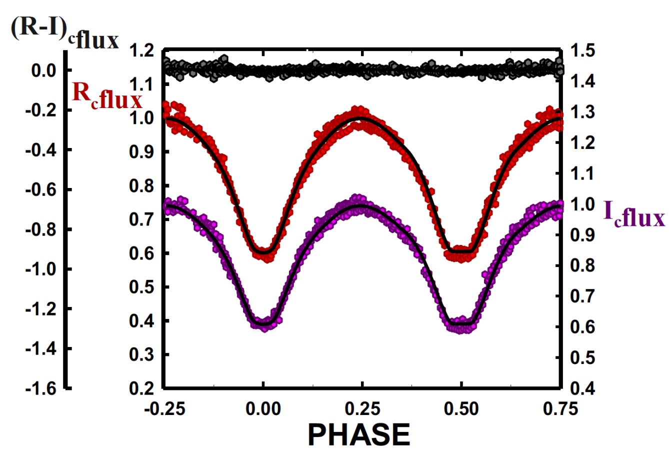

Figure 8b. MT Cam, Rc,Ic and Rc-Ic normalized fluxes overlaid by the light curve solution.

undersized. The W-type phenomena has been noted particularly on W UMa binaries that undergo interchanging depths, transit minima, and asymmetric light curves—all due to heavy spot activity (Kang *et al.* 2002). Thus, spots play a key role in this phenomena. The secondary component has a temperature of ~5645 K. Since our modeling (beginning with BINARY MAKER 3.0 fits) was done independently of TGC's, the remarkable agreement achieved shows Wilson code results are reliable. Of course, the present observations were taken 1.8 years later than the last curves by TGC, so some variation is expected.

9. Conclusions

The period study of this overcontact W UMa binary has a 15-year time duration. The period is found to be decreasing, marginally, at about the 1.5 sigma level. If the period is truly constantly decreasing, it may be due to angular momentum loss due to magnetic braking. The bifurcation in the R mag curve about phase 0.25 and I at phase 0.50 demonstrates night-to-night variation due to this solar activity. If this is the case, the system will slowly coalesce over time. In time, if this continues, one would theorize that the binary will become a rather normal, fast rotating, single G0V type field star after a small mass loss. This will probably occur following a red novae coalescence event (Tylenda and Kamiński 2016). We remind the reader that radial velocity curves are needed to obtain absolute (not relative) system parameters.

10. Acknowledgements

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Table 1. MT Cam observations, ΔB, ΔV, $ΔR_c$, and $ΔI_c$, variable star minus comparison star.

ΔB	HJD 2458000+	ΔB	HJD 2458000+	ΔB	HJD 2458000+	ΔB	HJD 2458000+	ΔB	HJD 2458000+
0.214	92.47346	0.308	92.69429	–0.176	101.91692	0.390	102.75267	–0.155	103.55344
0.305	92.47743	0.212	92.69713	–0.188	101.91884	0.377	102.75459	–0.161	103.55652
0.312	92.47919	0.147	92.69999	–0.184	101.92076	0.365	102.75650	–0.155	103.55961
0.349	92.48095	0.182	92.70284	–0.181	101.92268	0.321	102.75842	–0.170	103.56298
0.361	92.48271	0.133	92.70568	–0.186	101.92460	0.320	102.76033	–0.177	103.56513
0.408	92.48612	0.021	92.70853	–0.177	101.92653	0.274	102.76225	–0.160	103.56729
0.399	92.48816	0.111	92.71138	–0.201	101.92845	0.244	102.76416	–0.157	103.56944
0.412	92.49021	0.128	92.71422	–0.167	101.93037	0.198	102.76608	–0.158	103.57160
0.416	92.49226	0.011	92.71707	–0.179	101.93229	0.181	102.76799	–0.161	103.57376
0.406	92.49431	0.014	92.71992	–0.174	101.93421	0.150	102.76991	–0.165	103.57592
0.415	92.49720	–0.088	92.72277	–0.187	101.93613	0.122	102.77184	–0.154	103.57806
0.390	92.49925	–0.069	92.72561	–0.181	101.93805	0.103	102.77375	–0.156	103.58023
0.400	92.50128	–0.058	92.72846	–0.165	101.93997	0.075	102.77567	–0.147	103.58238
0.413	92.50333	–0.059	92.73131	–0.161	101.94190	0.064	102.77758	–0.163	103.58454
0.349	92.50538	–0.103	92.73414	–0.151	101.94381	0.048	102.77950	–0.143	103.58670
0.336	92.50743	–0.111	92.73700	–0.165	101.94573	0.034	102.78142	–0.144	103.58885
0.288	92.51045	–0.153	92.73985	–0.147	101.94765	–0.016	102.78526	–0.134	103.59101
0.260	92.51249	–0.147	92.74553	–0.141	101.94957	–0.015	102.78718	–0.122	103.59318
0.233	92.51452	–0.170	92.74838	–0.144	101.95148	–0.030	102.78909	–0.112	103.59532
0.194	92.51656	–0.160	92.75123	–0.108	101.95340	–0.049	102.79101	–0.119	103.59747
0.189	92.51861	0.418	101.82600	–0.105	101.95532	–0.064	102.79294	–0.100	103.59964
0.125	92.52065	0.423	101.83058	–0.102	101.95723	–0.066	102.79486	–0.094	103.60179
0.113	92.52268	0.421	101.83249	–0.078	101.95914	–0.079	102.79677	–0.086	103.60394
0.094	92.52471	0.423	101.83440	–0.091	101.96106	–0.096	102.79868	–0.083	103.60610
0.062	92.52675	0.413	101.83632	–0.065	101.96297	–0.106	102.80060	–0.052	103.60826
0.041	92.52880	0.407	101.83824	–0.077	101.96489	–0.108	102.80252	–0.055	103.61041
0.015	92.53082	0.405	101.84016	–0.072	101.96680	–0.119	102.80444	–0.045	103.61259
0.012	92.53287	0.382	101.84209	–0.046	101.96872	–0.126	102.80635	–0.025	103.61474
–0.006	92.53491	0.361	101.84400	–0.041	101.97063	–0.140	102.80827	–0.005	103.61691
–0.008	92.53694	0.342	101.84592	–0.027	101.97256	–0.145	102.81019	–0.012	103.61906
–0.013	92.53897	0.309	101.84785	–0.010	101.97447	–0.147	102.81211	0.019	103.62122
–0.067	92.54101	0.273	101.84975	0.036	101.97639	–0.149	102.81404	0.045	103.62338
–0.030	92.54303	0.244	101.85166	0.015	101.97831	–0.169	102.81596	0.068	103.62554
–0.112	92.54508	0.209	101.85357	0.069	101.98023	–0.163	102.81788	0.086	103.62772
–0.090	92.54711	0.184	101.85550	0.078	101.98215	–0.172	102.81979	0.115	103.62987
–0.082	92.54914	0.150	101.85741	–0.096	102.69307	–0.175	102.82171	0.153	103.63203
–0.111	92.55118	0.129	101.85933	–0.081	102.69500	–0.177	102.82363	0.165	103.63419
–0.086	92.55321	0.098	101.86125	–0.073	102.69692	–0.193	102.82554	0.195	103.63634
–0.125	92.55524	0.085	101.86317	–0.048	102.69884	–0.187	102.82746	0.230	103.63850
–0.117	92.55727	0.053	101.86509	–0.049	102.70076	–0.191	102.82938	0.272	103.64067
–0.135	92.55931	0.036	101.86701	–0.047	102.70269	–0.195	102.83132	0.288	103.64282
–0.142	92.56134	0.019	101.86893	–0.022	102.70461	–0.192	102.83324	0.324	103.64498
–0.141	92.56338	0.012	101.87085	–0.014	102.70654	0.416	103.48052	0.365	103.64714
–0.161	92.56542	–0.015	101.87278	0.017	102.70846	0.431	103.48335	0.405	103.64929
–0.164	92.56745	–0.022	101.87470	0.029	102.71039	0.401	103.48618	0.414	103.65145
–0.163	92.56948	–0.022	101.87662	0.036	102.71231	0.376	103.48901	0.409	103.65362
–0.169	92.57150	–0.043	101.87854	0.068	102.71423	0.344	103.49185	0.412	103.65578
–0.161	92.57354	–0.059	101.88046	0.085	102.71615	0.302	103.49494	0.419	103.65794
–0.178	92.57557	–0.072	101.88238	0.114	102.71807	0.251	103.49802	0.419	103.66010
–0.201	92.57760	–0.080	101.88430	0.128	102.72001	0.187	103.50110	0.409	103.66225
–0.171	92.57964	–0.075	101.88622	0.151	102.72193	0.164	103.50417	0.403	103.66441
–0.189	92.58168	–0.099	101.88815	0.186	102.72386	0.127	103.50725	0.439	103.66657
–0.177	92.58371	–0.103	101.89006	0.225	102.72578	0.085	103.51033	0.412	103.66872
–0.177	92.58575	–0.117	101.89198	0.235	102.72770	0.053	103.51341	0.400	103.67088
–0.150	92.58778	–0.118	101.89389	0.282	102.72963	0.025	103.51650	0.379	103.67303
–0.175	92.58981	–0.113	101.89581	0.293	102.73155	0.000	103.51958	0.356	103.67517
–0.137	92.59184	–0.121	101.89773	0.335	102.73347	–0.023	103.52266	0.326	103.67733
–0.184	92.59387	–0.151	101.89965	0.359	102.73539	–0.048	103.52572	0.284	103.67950
–0.147	92.59590	–0.145	101.90156	0.352	102.73731	–0.053	103.52882	0.264	103.68166
–0.142	92.59794	–0.133	101.90348	0.379	102.73923	–0.058	103.53189	0.224	103.68383
–0.145	92.61220	–0.168	101.90540	0.385	102.74115	–0.087	103.53497	0.183	103.68598
0.389	92.68006	–0.157	101.90731	0.406	102.74306	–0.111	103.53806	0.162	103.68813
0.397	92.68290	–0.170	101.90923	0.406	102.74498	–0.114	103.54113	0.135	103.69029
0.380	92.68575	–0.173	101.91116	0.402	102.74692	–0.124	103.54421	0.110	103.69244
0.369	92.68860	–0.158	101.91308	0.392	102.74884	–0.135	103.54729	0.095	103.69460
0.357	92.69145	–0.180	101.91500	0.395	102.75076	–0.143	103.55037	0.056	103.69677

Table continued on following pages

Table 1. MT Cam observations, ΔB, ΔV, $ΔR_c$, and $ΔI_c$, variable star minus comparison star, cont.

Δ*B*	*HJD 2458000+*	Δ*B*	*HJD 2458000+*	Δ*B*	*HJD 2458000+*	Δ*B*	*HJD 2458000+*	Δ*B*	*HJD 2458000+*
0.037	103.69892	–0.173	104.48841	0.379	104.58813	–0.121	104.68783	–0.072	104.82039
0.026	103.70107	–0.163	104.49100	0.301	104.59098	–0.118	104.69068	–0.085	104.82487
–0.006	103.70322	–0.164	104.49360	0.301	104.59098	–0.109	104.69353	–0.118	104.82934
–0.019	103.70539	–0.150	104.49619	0.295	104.59384	–0.099	104.69637	–0.159	104.83379
–0.028	103.70754	–0.151	104.49878	0.243	104.59671	–0.096	104.69922	–0.140	104.83828
–0.048	103.70969	–0.160	104.50136	0.211	104.59956	–0.079	104.70206	–0.157	104.84275
–0.051	103.71187	–0.144	104.50396	0.158	104.60242	–0.087	104.70490	–0.171	104.84723
–0.061	103.71402	–0.139	104.50655	0.160	104.60526	–0.103	104.70776	–0.148	104.85170
–0.076	103.71619	–0.131	104.50913	0.097	104.60811	–0.038	104.71062	–0.161	104.85618
–0.076	103.71833	–0.123	104.51172	0.063	104.61096	0.010	104.71347	0.145	104.86065
–0.096	103.72051	–0.105	104.51431	0.057	104.61382	–0.015	104.71633	–0.138	104.86511
–0.099	103.72267	–0.127	104.51690	0.020	104.61666	0.029	104.71919	–0.150	104.86959
–0.106	103.72483	–0.119	104.51973	0.008	104.61951	0.080	104.72203	–0.152	104.87406
–0.119	103.72700	–0.039	104.52258	–0.018	104.62236	0.057	104.72487	–0.127	104.87853
–0.120	103.72915	–0.064	104.52541	–0.030	104.62522	0.095	104.72772	–0.097	104.88299
–0.127	103.73130	–0.070	104.52827	–0.052	104.62808	0.148	104.73055	–0.079	104.88747
–0.127	103.73347	–0.027	104.53111	–0.071	104.63092	0.154	104.73340	–0.068	104.89196
–0.148	103.73597	–0.011	104.53397	–0.083	104.63377	0.217	104.73626	–0.033	104.89643
–0.154	103.73814	–0.002	104.53680	–0.082	104.63662	0.269	104.73912	–0.009	104.90090
–0.160	103.74031	0.041	104.53965	–0.101	104.63948	0.327	104.74375	0.026	104.90538
–0.154	103.74247	0.063	104.54250	–0.111	104.64232	0.309	104.74821	0.065	104.90986
–0.158	103.74464	0.092	104.54534	–0.122	104.64517	0.419	104.75269	0.132	104.91433
–0.164	103.74679	0.121	104.54819	–0.147	104.64802	0.413	104.75717	0.176	104.91882
–0.148	103.74895	0.167	104.55105	–0.141	104.65087	0.430	104.76165	0.274	104.92327
–0.167	103.75112	0.199	104.55391	–0.147	104.65371	0.436	104.76613	0.049	104.92775
–0.170	103.75327	0.240	104.55674	–0.159	104.65656	0.407	104.77060	–0.016	104.93222
–0.205	103.75544	0.269	104.55959	–0.155	104.65940	0.349	104.77508	–0.263	104.93670
–0.176	103.75759	0.327	104.56245	–0.161	104.66225	0.254	104.78015	–0.455	104.94117
–0.210	103.75976	0.363	104.56530	–0.170	104.66510	0.161	104.78463	–0.157	104.94565
–0.164	103.76180	0.398	104.56815	–0.164	104.66794	0.089	104.78911	0.411	104.95012
–0.154	103.76398	0.407	104.57102	–0.164	104.67077	0.070	104.79357	0.349	104.95460
–0.161	103.76612	0.422	104.57387	–0.154	104.67362	0.020	104.79804	–0.210	104.95908
–0.184	103.76828	0.438	104.57672	–0.154	104.67646	0.009	104.80250		
–0.151	104.48063	0.426	104.57958	–0.141	104.67930	–0.024	104.80696		
–0.169	104.48323	0.421	104.58243	–0.137	104.68214	–0.041	104.81143		
–0.160	104.48582	0.378	104.58529	–0.143	104.68500	–0.066	104.81591		

Δ*V*	*HJD 2458000+*	Δ*V*	*HJD 2458000+*	Δ*V*	*HJD 2458000+*	Δ*V*	*HJD 2458000+*	Δ*V*	*HJD 2458000+*
0.218	92.47403	0.022	92.52949	–0.194	92.58035	0.113	92.70383	0.173	101.85422
0.266	92.47801	0.001	92.53154	–0.193	92.58238	0.080	92.70668	0.163	101.85614
0.314	92.47976	–0.012	92.53358	–0.185	92.58442	0.069	92.70952	0.106	101.85807
0.331	92.48152	–0.017	92.53561	–0.195	92.58645	0.025	92.71237	0.079	101.85997
0.348	92.48327	–0.049	92.53765	–0.202	92.58848	–0.077	92.71522	0.063	101.86190
0.378	92.48683	–0.116	92.53968	–0.195	92.59051	0.014	92.71807	0.045	101.86383
0.374	92.48888	–0.058	92.54171	–0.184	92.59255	–0.006	92.72091	0.015	101.86575
0.383	92.49093	–0.060	92.54375	–0.193	92.59457	–0.074	92.72376	–0.004	101.86767
0.381	92.49297	–0.114	92.54577	0.004	92.59661	–0.048	92.72661	0.005	101.86959
0.383	92.49502	–0.133	92.54781	0.019	92.59865	–0.101	92.72946	–0.021	101.87151
0.383	92.49792	–0.140	92.54984	–0.160	92.60068	–0.311	92.73230	–0.055	101.87344
0.366	92.49995	–0.115	92.55187	–0.232	92.60883	–0.094	92.73515	–0.038	101.87536
0.366	92.50200	–0.144	92.55391	–0.081	92.61087	0.382	101.82665	–0.068	101.87728
0.374	92.50404	–0.151	92.55594	–0.091	92.61290	0.371	101.83121	–0.060	101.87920
0.329	92.50609	–0.143	92.55797	–0.123	92.61493	0.377	101.83313	–0.081	101.88112
0.283	92.50814	–0.156	92.56001	0.362	92.67537	0.378	101.83506	–0.081	101.88304
0.253	92.51116	–0.160	92.56205	0.366	92.67821	0.379	101.83698	–0.101	101.88496
0.208	92.51319	–0.168	92.56409	0.352	92.68105	0.370	101.83890	–0.122	101.88687
0.184	92.51523	–0.169	92.56612	0.382	92.68390	0.365	101.84082	–0.138	101.88879
0.172	92.51728	–0.184	92.56815	0.331	92.68675	0.338	101.84274	–0.106	101.89070
0.114	92.51932	–0.182	92.57017	0.360	92.68959	0.310	101.84466	–0.122	101.89263
0.103	92.52135	–0.176	92.57221	0.275	92.69244	0.283	101.84657	–0.154	101.89455
0.096	92.52338	–0.190	92.57424	0.226	92.69529	0.247	101.84848	–0.142	101.89647
0.114	92.52543	–0.199	92.57627	0.191	92.69814	0.233	101.85039	–0.159	101.89839
0.033	92.52746	–0.200	92.57831	0.165	92.70098	0.196	101.85231	–0.154	101.90029

Table continued on following pages

Table 1. MT Cam observations, ΔB, ΔV, $ΔR_c$, and $ΔI_c$, variable star minus comparison star, cont.

ΔV	HJD 2458000+	ΔV	HJD 2458000+	ΔV	HJD 2458000+	ΔV	HJD 2458000+	ΔV	HJD 2458000+
–0.147	101.90221	0.349	102.73797	0.177	103.50221	0.372	103.66506	–0.107	104.52356
–0.179	101.90413	0.364	102.73989	0.124	103.50529	0.398	103.66723	–0.095	104.52642
–0.182	101.90605	0.372	102.74180	0.103	103.50838	0.404	103.66938	–0.085	104.52927
–0.198	101.91182	0.370	102.74373	0.058	103.51145	0.385	103.67152	–0.077	104.53210
–0.183	101.91374	0.372	102.74565	0.019	103.51454	0.358	103.67367	–0.033	104.53495
–0.184	101.91566	0.366	102.74757	0.004	103.51762	0.334	103.67584	–0.030	104.53780
–0.204	101.91758	0.366	102.74949	–0.024	103.52070	0.303	103.67800	0.014	104.54065
–0.199	101.91950	0.370	102.75140	–0.041	103.52378	0.273	103.68015	0.039	104.54349
–0.199	101.92142	0.365	102.75332	–0.059	103.52685	0.239	103.68233	0.070	104.54635
–0.197	101.92334	0.353	102.75523	–0.070	103.52993	0.186	103.68448	0.098	104.54920
–0.194	101.92525	0.325	102.75716	–0.089	103.53301	0.164	103.68663	0.140	104.55205
–0.202	101.92717	0.300	102.75907	–0.098	103.53610	0.126	103.68879	0.179	104.55490
–0.185	101.92910	0.272	102.76099	–0.122	103.53918	0.117	103.69094	0.219	104.55774
–0.172	101.93103	0.247	102.76291	–0.129	103.54225	0.087	103.69309	0.268	104.56059
–0.188	101.93295	0.216	102.76482	–0.134	103.54533	0.055	103.69527	0.301	104.56345
–0.171	101.93487	0.184	102.76673	–0.144	103.54841	0.030	103.69742	0.332	104.56629
–0.166	101.93679	0.156	102.76866	–0.154	103.55148	0.010	103.69957	0.361	104.56915
–0.196	101.93871	0.131	102.77058	–0.163	103.55457	–0.003	103.70173	0.380	104.57201
–0.180	101.94062	0.112	102.77249	–0.165	103.55765	–0.026	103.70389	0.382	104.57487
–0.152	101.94253	0.071	102.77440	–0.172	103.56073	–0.030	103.70603	0.385	104.57773
–0.195	101.94445	0.065	102.77632	–0.168	103.56364	–0.043	103.70820	0.374	104.58058
–0.163	101.94638	0.036	102.77823	–0.166	103.56579	–0.049	103.71036	0.375	104.58343
–0.158	101.94830	0.018	102.78016	–0.182	103.56794	–0.074	103.71253	0.345	104.58628
–0.103	101.95021	0.005	102.78207	–0.185	103.57010	–0.071	103.71468	0.331	104.58913
–0.136	101.95214	–0.016	102.78400	–0.165	103.57226	–0.084	103.71683	0.276	104.59199
–0.127	101.95406	–0.042	102.78592	–0.167	103.57441	–0.080	103.71900	0.249	104.59485
–0.112	101.95596	–0.053	102.78784	–0.163	103.57657	–0.103	103.72116	0.190	104.59771
–0.099	101.95788	–0.065	102.78975	–0.164	103.57872	–0.103	103.72332	0.170	104.60055
–0.114	101.95980	–0.074	102.79167	–0.165	103.58088	–0.117	103.72549	0.121	104.60341
–0.030	101.96171	–0.085	102.79359	–0.163	103.58304	–0.116	103.72764	0.079	104.60626
–0.111	101.96362	–0.086	102.79551	–0.152	103.58520	–0.128	103.72979	0.063	104.60911
–0.079	101.96553	–0.105	102.79742	–0.147	103.58735	–0.140	103.73196	0.017	104.61196
–0.073	101.96745	–0.111	102.79933	–0.149	103.58952	–0.147	103.73413	–0.003	104.61481
–0.038	101.96937	–0.119	102.80125	–0.147	103.59167	–0.151	103.73663	–0.031	104.61766
–0.033	101.97128	–0.124	102.80317	–0.138	103.59382	–0.164	103.73880	–0.047	104.62049
–0.038	101.97320	–0.136	102.80510	–0.127	103.59598	–0.165	103.74096	–0.054	104.62335
–0.011	101.97513	–0.147	102.80702	–0.123	103.59813	–0.171	103.74313	–0.081	104.62621
0.046	101.97705	–0.151	102.80893	–0.097	103.60029	–0.167	103.74528	–0.095	104.62907
0.013	101.97897	–0.157	102.81085	–0.097	103.60460	–0.166	103.74746	–0.103	104.63192
0.018	101.98089	–0.167	102.81278	–0.084	103.60676	–0.174	103.74961	–0.117	104.63477
0.091	101.98281	–0.172	102.81469	–0.062	103.60891	–0.174	103.75177	–0.128	104.63761
0.091	101.98281	–0.179	102.81661	–0.044	103.61108	–0.177	103.75393	–0.137	104.64047
0.091	101.98281	–0.188	102.81852	–0.039	103.61324	–0.172	103.75826	–0.155	104.64333
–0.108	102.69373	–0.187	102.82044	–0.045	103.61540	–0.181	103.76042	–0.158	104.64617
–0.105	102.69565	–0.191	102.82236	–0.019	103.61756	–0.175	103.76247	–0.149	104.64901
–0.098	102.69757	–0.203	102.82429	–0.011	103.61971	–0.160	103.76462	–0.187	104.65186
–0.082	102.69949	–0.200	102.82621	0.023	103.62187	–0.208	103.76677	–0.175	104.65470
–0.070	102.70141	–0.208	102.82813	0.029	103.62404	–0.171	103.76894	–0.185	104.65754
–0.056	102.70335	–0.207	102.83005	0.057	103.62619	–0.175	103.77109	–0.187	104.66039
–0.044	102.70526	–0.197	102.83197	0.092	103.62836	–0.150	103.77324	–0.183	104.66325
–0.023	102.70719	–0.205	102.83389	0.102	103.63052	–0.183	104.48157	–0.190	104.66609
–0.006	102.70912	–0.197	102.83581	0.131	103.63269	–0.193	104.48416	–0.186	104.66893
0.011	102.71104	–0.208	102.83773	0.171	103.63484	–0.194	104.48674	–0.181	104.67178
0.037	102.71297	–0.177	102.83966	0.199	103.63701	–0.196	104.48934	–0.183	104.67462
0.053	102.71488	–0.183	102.84158	0.235	103.63916	–0.191	104.49194	–0.173	104.67745
0.071	102.71681	–0.199	102.84350	0.240	103.64132	–0.193	104.49453	–0.174	104.68030
0.090	102.71874	–0.192	102.84542	0.297	103.64348	–0.197	104.49713	–0.168	104.68313
0.123	102.72066	–0.227	102.84734	0.329	103.64563	–0.200	104.49971	–0.160	104.68599
0.152	102.72260	–0.227	102.84734	0.350	103.64779	–0.175	104.50230	–0.154	104.68883
0.175	102.72451	0.425	103.48158	0.380	103.64994	–0.176	104.50488	–0.143	104.69169
0.209	102.72644	0.391	103.48441	0.386	103.65212	–0.165	104.50747	–0.136	104.69453
0.241	102.72836	0.349	103.48724	0.399	103.65427	–0.154	104.51007	–0.132	104.69737
0.266	102.73028	0.332	103.49007	0.386	103.65644	–0.138	104.51266	–0.128	104.70021
0.289	102.73220	0.308	103.49298	0.382	103.65859	–0.153	104.51524	–0.114	104.70305
0.323	102.73412	0.257	103.49606	0.400	103.66076	–0.148	104.51789	–0.102	104.70591
0.336	102.73604	0.217	103.49913	0.393	103.66291	–0.127	104.52073	–0.107	104.70877

Table continued on following pages

Table 1. MT Cam observations, ΔB, ΔV, ΔR_c, and ΔI_c, variable star minus comparison star, cont.

ΔV	*HJD 2458000+*	*ΔV*	*HJD 2458000+*	*ΔV*	*HJD 2458000+*	*ΔV*	*HJD 2458000+*	*ΔV*	*HJD 2458000+*
–0.067	104.71163	0.335	104.74532	0.002	104.79515	–0.170	104.84881	–0.014	104.90247
–0.060	104.71448	0.242	104.74979	–0.091	104.79960	–0.206	104.85328	0.005	104.90695
–0.039	104.71734	0.389	104.75428	–0.042	104.80407	–0.178	104.85775	0.042	104.91143
–0.004	104.72018	0.363	104.75876	–0.078	104.80854	–0.184	104.86669	0.119	104.91590
–0.002	104.72302	0.384	104.76323	–0.103	104.81302	–0.170	104.87117	0.200	104.92038
0.049	104.72587	0.389	104.76772	–0.100	104.81750	–0.156	104.87563	0.197	104.92485
0.121	104.72871	0.343	104.77217	–0.110	104.82196	–0.144	104.88010	0.199	104.92615
0.139	104.73156	0.284	104.77665	–0.163	104.83091	–0.127	104.88457	0.256	104.95301
0.164	104.73441	0.217	104.78173	–0.168	104.83538	–0.110	104.88906		
0.219	104.73727	0.167	104.78621	–0.163	104.83986	–0.081	104.89354		
0.233	104.74011	0.136	104.79068	–0.184	104.84433	–0.057	104.89801		

ΔR_c	*HJD 2458000+*	ΔR_c	*HJD 2458000+*	ΔR_c	*HJD 2458000+*	ΔR_c	*HJD 2458000+*	ΔR_c	*HJD 2458000+*
0.158	92.47263	–0.218	92.57867	0.346	101.83349	–0.176	101.93331	0.361	102.74409
0.241	92.47661	–0.209	92.58071	0.350	101.83541	–0.224	101.93522	0.359	102.74601
0.272	92.47837	–0.201	92.58274	0.355	101.83732	–0.225	101.93715	0.359	102.74793
0.287	92.48013	–0.194	92.58478	0.346	101.83925	–0.218	101.93906	0.355	102.74985
0.313	92.48187	–0.187	92.58680	0.341	101.84118	–0.184	101.94289	0.354	102.75176
0.341	92.48515	–0.210	92.58884	0.294	101.84309	–0.173	101.94481	0.345	102.75368
0.372	92.48719	–0.195	92.59087	0.278	101.84502	–0.137	101.94673	0.326	102.75559
0.353	92.48924	–0.150	92.59290	0.252	101.84693	–0.145	101.94866	0.298	102.75751
0.355	92.49128	–0.162	92.59493	0.220	101.84884	–0.119	101.95249	0.283	102.75942
0.359	92.49333	–0.159	92.59697	0.204	101.85075	–0.156	101.95441	0.252	102.76135
0.367	92.49623	–0.125	92.59900	0.162	101.85267	–0.104	101.96015	0.225	102.76327
0.360	92.49827	0.342	92.60104	0.143	101.85458	–0.101	101.96207	0.198	102.76518
0.373	92.50031	0.363	92.60919	0.112	101.85650	–0.120	101.96398	0.198	102.76709
0.355	92.50236	0.372	92.61123	0.103	101.85841	–0.109	101.96589	0.149	102.76902
0.337	92.50441	0.327	92.61326	0.064	101.86033	–0.069	101.96781	0.121	102.77093
0.297	92.50645	0.283	92.61529	0.051	101.86225	–0.056	101.96972	0.100	102.77285
0.242	92.50947	0.252	92.61632	0.021	101.86419	–0.027	101.97164	0.077	102.77476
0.249	92.51152	0.256	92.67294	–0.001	101.86610	–0.049	101.97356	0.048	102.77668
0.204	92.51355	0.270	92.67583	–0.017	101.86994	–0.056	101.97547	0.386	103.47915
0.154	92.51559	0.120	92.67868	–0.045	101.87186	–0.053	101.97739	0.399	103.48204
0.138	92.51764	0.109	92.68153	–0.066	101.87378	0.030	101.97932	0.393	103.48487
0.117	92.51968	0.052	92.68437	–0.088	101.87764	0.023	101.98125	0.355	103.48769
0.099	92.52171	0.039	92.68722	–0.083	101.87955	0.077	101.98317	0.326	103.49053
0.074	92.52374	–0.057	92.69007	–0.107	101.88147	–0.119	102.69228	0.278	103.49350
0.031	92.52579	–0.055	92.69292	–0.086	101.88339	–0.120	102.69409	0.260	103.49658
0.013	92.52782	–0.070	92.69575	–0.125	101.88532	–0.114	102.69601	0.209	103.49966
0.004	92.52985	–0.087	92.69861	–0.120	101.88723	–0.089	102.69793	0.165	103.50274
–0.015	92.53190	–0.126	92.70146	–0.114	101.88915	–0.090	102.69985	0.115	103.50582
–0.037	92.53393	–0.123	92.70430	–0.140	101.89106	–0.077	102.70179	0.092	103.50891
–0.031	92.53597	–0.129	92.70715	–0.146	101.89298	–0.060	102.70371	0.051	103.51197
–0.071	92.53800	–0.171	92.71000	–0.149	101.89491	–0.049	102.70563	0.027	103.51507
–0.070	92.54003	–0.147	92.71285	–0.160	101.89683	–0.032	102.70755	0.008	103.51814
–0.103	92.54206	–0.198	92.71569	–0.154	101.89874	–0.015	102.70948	–0.010	103.52122
–0.137	92.54411	–0.192	92.71854	–0.166	101.90065	0.012	102.71140	–0.043	103.52430
–0.106	92.54613	0.362	92.72139	–0.197	101.90257	0.034	102.71332	–0.059	103.52738
–0.111	92.54817	0.341	92.72424	–0.162	101.90449	0.042	102.71525	–0.068	103.53046
–0.121	92.55021	0.343	92.72708	–0.175	101.90640	0.079	102.71717	–0.078	103.53354
–0.159	92.55223	0.347	92.72993	–0.200	101.90833	0.098	102.71910	–0.092	103.53663
–0.166	92.55427	0.346	92.73277	–0.203	101.91025	0.119	102.72102	–0.108	103.53969
–0.148	92.55630	0.350	92.73562	–0.218	101.91217	0.156	102.72295	–0.118	103.54277
–0.163	92.55833	0.355	92.73847	–0.204	101.91408	0.176	102.72486	–0.132	103.54585
–0.169	92.56037	0.346	92.74132	–0.205	101.91600	0.202	102.72680	–0.134	103.54893
–0.176	92.56241	0.341	92.74701	–0.178	101.91794	0.232	102.72872	–0.141	103.55201
–0.175	92.56444	0.294	92.74985	–0.209	101.91986	0.258	102.73064	–0.146	103.55509
–0.180	92.56648	0.278	92.75271	–0.176	101.92178	0.293	102.73256	–0.154	103.55818
–0.173	92.56851	0.252	92.75555	–0.233	101.92370	0.308	102.73448	–0.166	103.56188
–0.184	92.57053	0.362	101.82509	–0.218	101.92561	0.326	102.73640	–0.165	103.56404
–0.196	92.57257	0.341	101.82701	–0.180	101.92753	0.338	102.73832	–0.161	103.56620
–0.190	92.57459	0.343	101.82965	–0.173	101.92945	0.353	102.74025	–0.163	103.56835
–0.196	92.57663	0.347	101.83157	–0.232	101.93139	0.353	102.74216	–0.165	103.57051

Table continued on following pages

Table 1. MT Cam observations, ΔB, ΔV, ΔR_c, and ΔI_c, variable star minus comparison star, cont.

ΔR_c	HJD 2458000+	ΔR_c	HJD 2458000+	ΔR_c	HJD 2458000+	ΔR_c	HJD 2458000+	ΔR_c	HJD 2458000+
–0.164	103.57267	0.373	103.67194	0.041	103.76935	0.216	104.59539	0.076	104.73209
–0.162	103.57482	0.347	103.67408	–0.145	103.77150	0.176	104.59824	0.15	104.73494
–0.159	103.57697	0.315	103.67625	0.521	103.77365	0.134	104.60109	0.204	104.73780
–0.154	103.57914	0.291	103.67841	–0.096	103.77581	0.102	104.60394	0.254	104.74150
–0.151	103.58129	0.259	103.68056	–0.199	104.47938	0.069	104.60679	0.319	104.74597
–0.149	103.58344	0.215	103.68274	–0.191	104.48203	0.026	104.60964	0.355	104.75045
–0.143	103.58561	0.184	103.68489	–0.201	104.48463	0.016	104.61250	0.318	104.75493
–0.142	103.58776	0.167	103.68704	–0.199	104.48722	–0.014	104.61534	0.342	104.75941
–0.135	103.58993	0.129	103.68920	–0.180	104.48981	–0.029	104.61819	0.367	104.76389
–0.128	103.59208	0.102	103.69135	–0.178	104.49240	–0.049	104.62104	0.359	104.76837
–0.122	103.59423	0.086	103.69350	–0.184	104.49500	–0.077	104.62390	0.317	104.77282
–0.109	103.59638	0.052	103.69568	–0.196	104.49759	–0.092	104.62676	0.248	104.77790
–0.095	103.59855	0.034	103.69783	–0.184	104.50018	–0.104	104.62960	0.18	104.78238
–0.095	103.60070	0.019	103.69998	–0.177	104.50276	–0.121	104.63245	0.239	104.78686
–0.092	103.60285	0.006	103.70214	–0.182	104.50536	–0.134	104.63530	0.129	104.79133
–0.085	103.60501	–0.018	103.70430	–0.167	104.50794	–0.14	104.63816	–0.026	104.80025
–0.077	103.60717	–0.028	103.70645	–0.162	104.51053	–0.145	104.64102	–0.056	104.80473
–0.052	103.60932	–0.036	103.70861	–0.154	104.51312	–0.159	104.64385	–0.073	104.80919
–0.057	103.61149	–0.051	103.71077	–0.153	104.51570	–0.162	104.64670	–0.096	104.81367
–0.044	103.61365	–0.067	103.71294	–0.140	104.51842	–0.178	104.64955	–0.102	104.81815
–0.020	103.61581	–0.069	103.71509	–0.134	104.52126	–0.181	104.65239	–0.09	104.82262
–0.018	103.61797	–0.079	103.71724	–0.100	104.52409	–0.197	104.65524	–0.146	104.83156
0.005	103.62012	–0.089	103.71941	–0.105	104.52695	–0.199	104.65808	–0.172	104.83603
0.027	103.62228	–0.094	103.72157	–0.094	104.52980	–0.192	104.66093	–0.197	104.84051
0.036	103.62445	–0.116	103.72373	–0.059	104.53265	–0.195	104.66378	–0.19	104.84499
0.063	103.62662	–0.108	103.72590	–0.047	104.53548	–0.198	104.66662	–0.2	104.84945
0.085	103.62877	–0.121	103.72805	–0.021	104.53834	–0.187	104.66946	–0.137	104.85392
0.108	103.63093	–0.119	103.73020	0.014	104.54119	–0.191	104.67230	–0.186	104.85840
0.141	103.63310	–0.129	103.73237	0.043	104.54402	–0.185	104.67515	–0.036	104.86287
0.172	103.63525	–0.138	103.73488	0.066	104.54688	–0.187	104.67798	–0.2	104.86735
0.203	103.63741	–0.147	103.73704	0.107	104.54973	–0.181	104.68083	–0.162	104.87628
0.234	103.63957	–0.148	103.73922	0.150	104.55259	–0.175	104.68368	–0.144	104.88075
0.263	103.64173	–0.155	103.74137	0.170	104.55544	–0.172	104.68651	–0.132	104.88522
0.301	103.64390	–0.156	103.74355	0.207	104.55827	–0.156	104.68936	–0.109	104.88971
0.324	103.64604	–0.161	103.74570	0.267	104.56112	–0.151	104.69222	–0.081	104.89419
0.384	103.65035	–0.169	103.74787	0.288	104.56398	–0.142	104.69507	–0.059	104.89865
0.387	103.65253	–0.161	103.75002	0.335	104.56683	–0.137	104.69790	–0.01	104.90313
0.391	103.65468	–0.157	103.75218	0.350	104.56970	–0.117	104.70074	0.006	104.90760
0.389	103.65685	–0.093	103.75434	0.380	104.57255	–0.111	104.70360	0.055	104.91208
0.390	103.65900	0.081	103.75650	0.351	104.57540	–0.033	104.71501	0.115	104.91656
0.399	103.66116	–0.172	103.75866	0.367	104.58111	–0.022	104.71787	0.209	104.92103
0.393	103.66332	–0.179	103.76083	0.377	104.58396	0.001	104.72071	0.235	104.92551
0.383	103.66547	–0.149	103.76288	0.332	104.58681	0.023	104.72355	–0.012	104.93892
0.393	103.66763	–0.159	103.76503	0.294	104.58966	0.039	104.72640	0.362	104.94339
0.381	103.66979	–0.156	103.76718	0.259	104.59252	0.087	104.72924	1.134	104.94787

ΔI_c	HJD 2458000+	ΔI_c	HJD 2458000+	ΔI_c	HJD 2458000+	ΔI_c	HJD 2458000+	ΔI_c	HJD 2458000+
0.152	92.47293	0.223	92.50978	–0.092	92.54236	–0.227	92.57693	0.302	92.68764
0.210	92.47691	0.206	92.51182	–0.153	92.54441	–0.232	92.57897	0.264	92.69049
0.231	92.47867	0.182	92.51385	–0.113	92.54643	–0.216	92.58101	0.217	92.69333
0.257	92.48043	0.134	92.51589	–0.137	92.54847	–0.235	92.58304	0.179	92.69617
0.293	92.48218	0.130	92.51794	–0.153	92.55051	–0.222	92.58508	0.070	92.69903
0.330	92.48545	0.097	92.51998	–0.177	92.55457	–0.213	92.58711	0.094	92.70187
0.331	92.48749	0.059	92.52201	–0.172	92.55660	–0.195	92.59117	0.049	92.70472
0.330	92.48954	0.031	92.52404	–0.172	92.55863	–0.182	92.59321	0.030	92.70757
0.329	92.49158	–0.007	92.52609	–0.187	92.56067	–0.190	92.59930	0.030	92.71042
0.333	92.49363	–0.031	92.52812	–0.187	92.56271	–0.228	92.61153	–0.039	92.71326
0.327	92.49653	–0.028	92.53015	–0.194	92.56474	–0.121	92.61356	–0.069	92.71611
0.301	92.49858	–0.036	92.53220	–0.187	92.56678	0.307	92.67341	–0.064	92.71896
0.337	92.50061	–0.057	92.53424	–0.201	92.56881	0.323	92.67625	–0.038	92.72180
0.319	92.50266	–0.098	92.53627	–0.199	92.57083	0.321	92.67910	–0.127	92.72465
0.281	92.50471	–0.073	92.53831	–0.213	92.57287	0.325	92.68194	–0.114	92.72750
0.253	92.50675	–0.098	92.54033	–0.214	92.57490	0.312	92.68479	–0.117	92.73035

Table continued on following pages

Table 1. MT Cam observations, ΔB, ΔV, ΔR_c, and ΔI_c, variable star minus comparison star, cont.

ΔI_c	HJD 2458000+	ΔI_c	HJD 2458000+	ΔI_c	HJD 2458000+	ΔI_c	HJD 2458000+	ΔI_c	HJD 2458000+
–0.200	92.73319	–0.138	101.96811	–0.164	102.80575	–0.129	103.59897	–0.208	103.75045
–0.133	92.73604	–0.101	101.97002	–0.170	102.80767	–0.116	103.60328	–0.191	103.75260
–0.151	92.73889	–0.089	101.97386	–0.183	102.80959	–0.096	103.60543	–0.200	103.75476
–0.154	92.74457	–0.016	101.97577	–0.184	102.81151	–0.093	103.60760	–0.166	103.75692
–0.207	92.75027	0.012	101.97769	–0.182	102.81344	–0.077	103.60975	–0.184	103.76119
–0.174	92.75312	0.037	101.97962	–0.199	102.81536	–0.074	103.61192	–0.191	103.76329
–0.182	92.75597	0.021	101.98154	–0.202	102.81728	–0.070	103.61408	–0.206	103.76545
0.318	101.82539	0.062	101.98347	–0.209	102.81919	–0.048	103.61624	–0.216	103.76761
0.340	101.82996	0.077	101.98317	–0.206	102.82111	–0.044	103.61839	–0.199	104.47980
0.297	101.83187	–0.139	102.69253	–0.213	102.82303	–0.018	103.62056	–0.195	104.48240
0.321	101.83378	–0.134	102.69440	–0.206	102.82494	0.004	103.62488	–0.208	104.48500
0.316	101.83570	–0.118	102.69632	–0.212	102.82686	0.058	103.62704	–0.209	104.48758
0.336	101.83763	–0.114	102.69824	–0.215	102.82879	0.073	103.62919	–0.210	104.49018
0.315	101.83955	–0.100	102.70016	–0.236	102.83072	0.088	103.63137	–0.203	104.49276
0.305	101.84148	–0.093	102.70209	–0.221	102.83264	0.116	103.63352	–0.194	104.49535
0.283	101.84339	–0.067	102.70401	–0.228	102.83456	0.145	103.63567	–0.193	104.49796
0.255	101.84531	–0.067	102.70594	–0.221	102.83648	0.276	103.64432	–0.202	104.50054
0.148	101.85296	–0.047	102.70786	–0.230	102.83840	0.301	103.64647	–0.195	104.50313
0.101	101.85488	–0.020	102.70979	–0.192	102.84032	0.321	103.64863	–0.187	104.50571
0.080	101.85680	–0.008	102.71171	–0.210	102.84224	0.346	103.65079	–0.173	104.50831
0.089	101.85871	0.005	102.71363	–0.183	102.84416	0.350	103.65295	–0.176	104.51089
0.031	101.86063	0.033	102.71555	0.353	103.47957	0.352	103.65512	–0.160	104.51348
0.017	101.86256	0.059	102.71747	0.338	103.48241	0.357	103.65727	–0.156	104.51607
–0.007	101.86448	0.080	102.71941	0.333	103.48523	0.363	103.65944	–0.152	104.51885
–0.012	101.86640	0.097	102.72133	0.326	103.48806	0.361	103.66159	–0.164	104.52169
–0.039	101.86832	0.131	102.72326	0.291	103.49088	0.352	103.66374	–0.142	104.52452
–0.042	101.87024	0.155	102.72518	0.239	103.49393	0.359	103.66591	–0.095	104.52738
–0.052	101.87216	0.180	102.72710	0.184	103.49701	0.360	103.66806	–0.089	104.53023
–0.087	101.87408	0.219	102.72903	0.149	103.50008	0.346	103.67021	–0.040	104.53307
–0.070	101.87600	0.240	102.73095	0.118	103.50316	0.337	103.67236	–0.043	104.53591
–0.109	101.87793	0.271	102.73287	0.081	103.50624	0.303	103.67451	–0.036	104.53877
–0.102	101.87985	0.280	102.73479	0.047	103.50932	0.279	103.67667	–0.022	104.54162
–0.129	101.88177	0.300	102.73671	0.015	103.51240	0.241	103.67883	0.028	104.54445
–0.132	101.88369	0.307	102.73863	–0.010	103.51548	0.219	103.68100	0.060	104.54730
–0.135	101.88561	0.305	102.74055	–0.030	103.51857	0.179	103.68316	0.077	104.55016
–0.147	101.88753	0.326	102.74246	–0.052	103.52165	0.158	103.68532	0.111	104.55302
–0.146	101.88945	0.317	102.74438	–0.090	103.52473	0.121	103.68747	0.169	104.55585
–0.169	101.89136	0.320	102.74632	–0.086	103.52780	0.101	103.68962	0.207	104.55870
–0.189	101.89328	0.329	102.74824	–0.097	103.53088	0.067	103.69177	0.248	104.56155
–0.170	101.89521	0.336	102.75016	–0.122	103.53397	0.047	103.69394	0.276	104.56441
–0.199	101.89713	0.331	102.75207	–0.129	103.53705	0.030	103.69610	0.305	104.56725
–0.155	101.89904	0.304	102.75399	–0.133	103.54012	0.005	103.69825	0.316	104.57012
–0.200	101.90095	0.279	102.75590	–0.150	103.54320	–0.001	103.70040	0.324	104.57298
–0.194	101.90479	0.274	102.75782	–0.166	103.54628	–0.033	103.70255	0.340	104.57583
–0.209	101.90670	0.252	102.75973	–0.173	103.54935	–0.026	103.70472	0.311	104.57869
–0.188	101.91054	0.229	102.76165	–0.167	103.55243	–0.052	103.70687	0.329	104.58154
–0.207	101.91246	0.189	102.76357	–0.170	103.55551	–0.074	103.70902	0.335	104.58439
–0.213	101.91631	0.166	102.76548	–0.181	103.55860	–0.073	103.71120	0.296	104.58724
–0.216	101.92208	0.143	102.76739	–0.184	103.56232	–0.085	103.71335	0.151	104.59866
–0.204	101.92399	0.040	102.77507	–0.184	103.56447	–0.100	103.71551	0.107	104.60151
–0.223	101.92591	0.029	102.77699	–0.192	103.56662	–0.106	103.71766	0.084	104.60437
–0.207	101.92783	0.010	102.77890	–0.189	103.56878	–0.108	103.71983	0.034	104.60722
–0.213	101.93169	–0.014	102.78082	–0.195	103.57094	–0.121	103.72199	0.014	104.61007
–0.204	101.93360	–0.044	102.78274	–0.192	103.57309	–0.132	103.72415	–0.015	104.61292
–0.229	101.93744	–0.051	102.78466	–0.178	103.57525	–0.135	103.72632	–0.039	104.61577
–0.223	101.94128	–0.071	102.78658	–0.188	103.57740	–0.146	103.72848	–0.072	104.61862
–0.183	101.94319	–0.075	102.78849	–0.190	103.57956	–0.144	103.73063	–0.086	104.62147
–0.182	101.94896	–0.092	102.79041	–0.175	103.58172	–0.161	103.73280	–0.098	104.62432
–0.125	101.95279	–0.100	102.79234	–0.177	103.58387	–0.160	103.73530	–0.121	104.62718
–0.159	101.95662	–0.119	102.79426	–0.170	103.58603	–0.168	103.73746	–0.124	104.63003
–0.107	101.95853	–0.128	102.79617	–0.159	103.58819	–0.168	103.73964	–0.133	104.63288
–0.137	101.96045	–0.133	102.79808	–0.161	103.59035	–0.177	103.74180	–0.149	104.63572
–0.143	101.96237	–0.150	102.80000	–0.145	103.59250	–0.178	103.74397	–0.155	104.63858
–0.139	101.96428	–0.148	102.80192	–0.147	103.59466	–0.185	103.74612	–0.152	104.64143
–0.132	101.96619	–0.158	102.80384	–0.132	103.59681	–0.165	103.74828	–0.189	104.64428

Table continued on next page

Table 1. MT Cam observations, ΔB, ΔV, $ΔR_c$, and $ΔI_c$, variable star minus comparison star, cont.

$ΔI_c$	HJD 2458000+	$ΔI_c$	HJD 2458000+	$ΔI_c$	HJD 2458000+	$ΔI_c$	HJD 2458000+	$ΔI_c$	HJD 2458000+
–0.206	104.64713	–0.175	104.69265	0.192	104.73822	–0.132	104.81880	–0.065	104.89931
–0.191	104.64997	–0.158	104.69549	0.245	104.74216	–0.181	104.82328	–0.043	104.90379
–0.215	104.65282	–0.138	104.69833	0.310	104.74663	–0.184	104.83221	0.026	104.90827
–0.191	104.65567	–0.148	104.70116	0.312	104.75111	–0.181	104.83670	0.045	104.91274
–0.203	104.65850	–0.128	104.70401	0.336	104.76454	–0.199	104.84116	0.102	104.91723
–0.208	104.66136	–0.115	104.70687	0.316	104.76902	–0.203	104.84564	0.146	104.92169
–0.211	104.66421	–0.121	104.70973	0.281	104.77348	–0.170	104.85011	0.200	104.92616
–0.202	104.66704	–0.092	104.71259	0.203	104.77856	–0.185	104.85459	0.308	104.94854
–0.205	104.66989	–0.080	104.71544	0.158	104.78304	–0.143	104.85906	0.256	104.95302
–0.203	104.67273	–0.050	104.71829	0.332	104.78752	–0.186	104.86801	0.303	104.95750
–0.210	104.67556	–0.041	104.72114	0.054	104.79199	–0.135	104.87247	0.256	104.45302
–0.199	104.67841	–0.009	104.72398	–0.023	104.79645	–0.175	104.87694	0.303	104.45750
–0.196	104.68125	0.048	104.72682	–0.053	104.80091	–0.144	104.88141	–0.835	104.43446
–0.187	104.68410	0.066	104.72966	–0.073	104.80539	–0.140	104.88589	–0.012	104.43893
–0.189	104.68694	0.110	104.73252	–0.101	104.80985	–0.133	104.89038	0.362	104.44340
–0.173	104.68979	0.146	104.73537	–0.121	104.81434	–0.086	104.89485	1.134	104.44788

Table 2. Information on the stars used in this study.

Star	Name	R.A. (2000) h m s	Dec. (2000) ° ′ ″	V	B	J–K
V	MT Cam MisV1226 GSC 3737-01085 USNO-A2.0 1425.05422897 IBVS 5600-77 2MASS J20535602-0632016 3UC167-320333	04 40 24.45	+55 25 14.4[1]	—	12.7[2]	0.450 ± 0.039[2]
C	GSC 3737-0670	04 40 56.3754	+55 22 14.215[1]	13.07[2]	—	0.42[2]
K (Check)	GSC 3737-01102 3UC291-070743	04 40 56.7551	+55 21 25.300[1]	12.65[2]	—	0.64[2]

[1] UCAC3 (*U.S. Naval Obs. 2012*). [2] *2MASS (Skrutskie et al. 2006).*

Table 3. O–C Residuals for MT Cam.

	Epoch 2400000+	Standard[1] Error	Cycle	Linear Residual[3]	Quadratic Residual[3]	Reference
1	52500.2629	0.0004	–15304.0	0.0008	0.0020	GCVS 5
2	52965.2530	—	–14034.0	–0.0063	–0.0058	Nakajima *et al.* 2005
3	52965.9883	—	–14032.0	–0.0033	–0.0028	Nakajima *et al.* 2005
4	52975.3257	—	–14006.5	–0.0025	–0.0020	Nakajima *et al.* 2005
5	52975.3307	0.0004	–14006.5	0.0025	0.0030	GCVS 4
6	53320.7834	—	–13063.0	0.0026	0.0026	TGC[2]
7	53330.6689	0.0003	–13036.0	0.0023	0.0024	TGC[2]
8	54173.3388	—	–10734.5	0.0020	0.0013	Diethelm 2007
9	54442.6343	0.0003	–9999.0	0.0019	0.0010	Nelson 2008
10	54831.6560	0.0024	–8936.5	0.0003	–0.0008	Diethelm 2009
11	55503.8891	0.0003	–7100.5	0.0012	0.0000	Diethelm 2011
12	55875.8871	0.0035	–6084.5	0.0014	0.0003	Diethelm 2012
13	56310.6764	0.0005	–4897.0	0.0000	–0.0010	Diethelm 2013
14	57429.7810	0.0005	–1840.5	–0.0010	–0.0012	TGC[2]
15	57431.6126	0.0004	–1835.5	0.0000	–0.0002	TGC[2]
16	57432.7108	0.0006	–1832.5	–0.0003	–0.0005	TGC[2]
17	58092.4937	0.0002	–30.5	–0.0008	–0.0002	Present observations
18	58102.7460	0.00007	–2.5	–0.0004	0.0001	Present observations
19	58103.6610	0.0001	0.0	–0.0008	–0.0002	Present observations
20	58104.5769	0.0002	2.5	–0.0003	0.0003	Present observations
21	58104.7607	0.0020	3.0	0.0005	0.0011	Present observations
22	58104.9434	0.0029	3.5	0.0001	0.0007	Present observations
	rms			0.00202	0.00190	

1. Published or calculated errors.
2. Calculated from the light curve data given in the reference.
3. The linear and quadratic ephemerides are given in Equations 1 and 2 respectively.

Table 4. Averaged light curve characteristics of MT Cam.

Filter	Phase	Magnitude Max. I	Phase	Magnitude Max. II
	0.25		0.75	
ΔB		–0.201 ± 0.015		–0.18 ± 0.019
ΔV		–0.188 ± 0.012		–0.184 ± 0.010
ΔR		–0.191 ± 0.021		–0.195 ± 0.024
ΔI		–0.213 ± 0.016		–0.2 ± 0.015

Filter	Phase	Magnitude Min. II	Phase	Magnitude Min. I
	0.50		0.00	
ΔB		0.415 ± 0.015		0.414 ± 0.013
ΔV		0.377 ± 0.014		0.378 ± 0.007
ΔR		0.365 ± 0.021		0.363 ± 0.010
ΔI		0.334 ± 0.022		0.329 ± 0.013

Filter	Phase Min. I – Max. I		Phase Max. I – Max. II		Phase Min. I – Min. II	
ΔB	0.615	±0.029	-0.021	±0.034	-0.001	±0.028
ΔV	0.566	±0.020	-0.005	±0.022	0.001	±0.021
ΔR	0.554	±0.031	0.004	±0.045	-0.001	±0.031
ΔI	0.542	±0.030	-0.013	±0.032	-0.006	±0.035

Filter	Phase Max. II –Max. I		Phase Min. II – Max. I	
ΔB	–0.015	±0.415	0.616	±0.030
ΔV	–0.012	±0.377	0.565	±0.026
ΔR	–0.021	±0.365	0.556	±0.043
ΔI	–0.016	±0.334	0.548	±0.038

Table 5. BVRI Solution Parameters, MT Cam.

Parameters	Overcontact Solution
λB, λV, λR,λI (nm)	440, 550, 640, 790
$x_{bol1,2}$, $y_{bol1,2}$	0.649 0 .649, 0.193, 0 .193
$x_{1I,2I}$, $y_{1I,2I}$	0.623, 0. 623, 0.230, 0.230
$x_{1R,2R}$, $y_{1R,2R}$	0.708, 0.708, 0. 229, 0.229
$x_{1V,2V}$, $y_{1V,2V}$	0.778, 0.778, 0. 200, 0. 200
$x_{1B,2B}$, $y_{1B,2B}$	0.847, 0.82479, 0.098, 0.098
g_1 , g_2	0.320,0.320
A_1 , A_2	0.5, 0.5
Inclination (°)	85.21 ± 0.15
T_1, T_2 (K)	5550, 5645 ± 1
$\Omega_1 = \Omega_2$ pot	2.522 ± 0.0012
$q(m_2 / m_1)$	0.3385 ± 0.0003
Fill-outs: $F_1 = F_2$ (%)	13 ± 1
$L_1 / (L_1 + L_2)_I$	0.7093 ± 0.0005
$L_1 / (L_1 + L_2)_R$	0.7064 ± 0.0006
$L_1 / (L_1 + L_2)_V$	0.7023 ± 0.0005
$L_1 / (L_1 + L_2)_B$	0.6934 ± 0.0005
JD_o (days)	2458102.74582 ± 0.00005
Period (days)	0.3661706 ± 0.0000003
r_1, r_2 (pole)	0. 452 ± 0.001, 0.276 ± 0.001
r_1, r_2 (side)	0.485 ± 0.001, 0.288 ± 0.001
r_1, r_2 (back)	0.513 ± 0.001, 0.325 ± 0.002