The First BVR$_c$I$_c$ Precision Observations and Preliminary Photometric Analysis of the Near Contact TYC 1488-693-1

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Abstract TYC 1488-693-1 is an ~F2 type (T ~ 6750 K) eclipsing binary. It was observed in April and May 2015 at Dark Sky Observatory in North Carolina with the 0.81-m reflector of Appalachian State University. Six times of minimum light were determined from our present observations, which include two primary eclipses and four secondary eclipses. In addition, six observations at minima were determined from archived NSVS Data. Improved linear and quadratic ephemerides were calculated from these times of minimum light which gave a possible period change of $dP/dt = -5.2(1.5) \times 10^{-6}$ d/yr. The period decrease may indicate that the binary is undergoing magnetic braking and is approaching a contact configuration due to the angular momentum loss. A BVR$_c$I$_c$ simultaneous Wilson-Devinney (WD) Program solution indicates that the system has a mass ratio ($q = M_2/M_1$) of ~0.58 (our solutions taken from q = 0.3 to 1.2 also indicate this is the value with the lowest sum of square residual), and a component temperature difference of ~2350 K. The large ΔT in the components verifies that the binary is not in contact. A BINARY MAKER fitted hot spot was maintained in the WD Synthetic Light Curve Computations. It remained on the larger component at the equator on the correct (following) side for a stream spot directed from the secondary component (as dictated by the Coriolis effect). This could indicate that the components are near filling their respective Roche Lobes. The fill-outs are nearly identical, 96% for the primary component and 95% for the secondary component. The inclination is ~79°, which is not enough for the system to undergo a total eclipse. Caution is given for taking this solution as the definitive one.

1. Introduction

We expect solar type contact binaries to have begun their evolution as pre-contact, detached binaries (Qian, Zhu, and Boonruksar 2006; Samec *et al.* 2015; Guinan and Bradstreet 1988). We are finding dwarf F though K type binaries in this configuration (Samec *et al.* 2017a; Samec *et al.* 2012). Magnetic braking is the probable physical mechanism responsible. TYC 1488-693-1 is such a binary. It apparently is near the detached-contact boundary of this evolution. We present a photometric analysis of this binary in the following sections.

2. History and observations

TYC 1488-693-1 (NSVS 10541123) is listed in the All Automated Sky Survey (Pojmański *et al.* 2013). Light curve data (Figure 1) are given at the NSVS website (Los Alamos Natl. Lab. 2017), which is a SkyDOT database for objects in time-domain. The binary is in the constellation of Cancer. The All Sky Automated Survey-3 (Pojmański *et al.* 2013) categorizes it as a semi-detached eclipsing binary (ESD) type with an amplitude of 0.71 V, and a period of 0.59549 d, ID = 145957+1938.6. VSX (Watson *et al.* 2014) gives magnitude range of V = 11.87 – 12.7 and characterizes it as an EA (Algol) type.

This system was observed as a part of our studies of interacting binaries from Shaw's Near Contact Binaries (e.g., Caton *et al.* 2018; Samec *et al.* 2016, 2017b) with data taken from Dark Sky Observatory observations (DSO; Appalachian State Univ. 2018). The curves shown are from the NSVS Catalog entry Object 10541123.

The new GAIA DR2 (Bailer-Jones 2015) results give a distance of 760 ±40 pc.

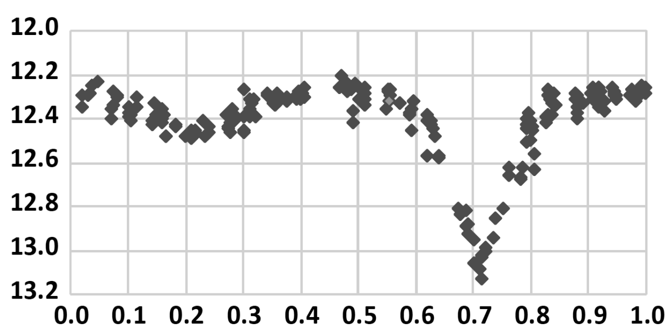

Figure 1. Data from the ASAS NSVS catalog entry object 10541123 (Los Alamos Natl. Lab. 2017).

Table 1. Information on the stars used in this study.

Star	*Name*	*R.A. (2000)* *h m s*	*Dec. (2000)* *° ′ ″*	*V*	*J–K*
V	NSVS 10541123 TYC 1488-693-1 ASAS 45957+1938.6 CRTS J145957.0+19383 2MASS J14595711+1938393	14 59 57.0904	+19 38 39.458	11.75[1]	0.18 ± 0.04[1]
C	TYC 1488-723-1	14 59 44.2342	+19 36 50.878	11.24[2]	0.34 ± 0.04[2]
K (Check)	TYC 1488-641-1 BD+20 3050	14 59 23.5159	+19 41 48.135[2]	10.51[2]	0.54 ± 0.08[2]

[1] 2MASS (Skrutskie et al. 2006). [2] ICRS (U. S. Naval Obs. 2018).

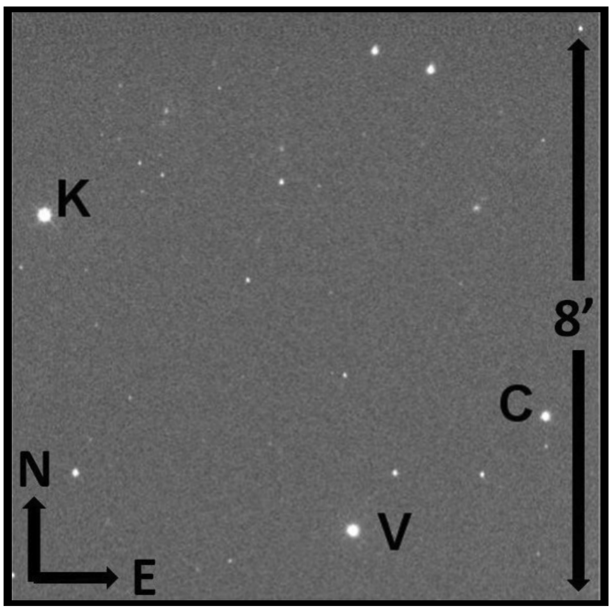

Figure 2. Finder chart showing V image of TYC 1488-693-1 (the variable V, the comparison star C, and the check star K).

Our BVR$_c$I$_c$ light curves were taken with the DSO 0.81-m f/8 R-C reflector at Philips Gap, North Carolina, on 1, 5, 24 April and 5, 6, 8, 9, 10 May 2015 with a thermoelectrically cooled (–40º C) 2K × 2K Apogee Alta by D. Caton, R. Samec, and D. Faulkner with BVR$_c$I$_c$ filters. Reductions were done with AIP4WIN V2. Individual observations included 751 in B, 566 in V, 767 in R$_c$, and 741 in I$_c$. The probable error of a single observation was 6 mmag B, 10 mmag in V, 6 mmag in R$_c$, and 7 mmag in I$_c$. The nightly C–K values stayed constant throughout the observing run with a precision of 0.1–1%. Exposure times varied from 100 s in B to 15 s in V, R$_c$, and I$_c$. Nightly Images were calibrated with 25 bias frames, at least five flat frames in each filter, and ten 300-s dark frames.

3. Stellar identifications and finding chart

The coordinates and magnitudes of the variable star, comparison star, and check star are given in Table 1. The finding chart is shown as Figure 2.

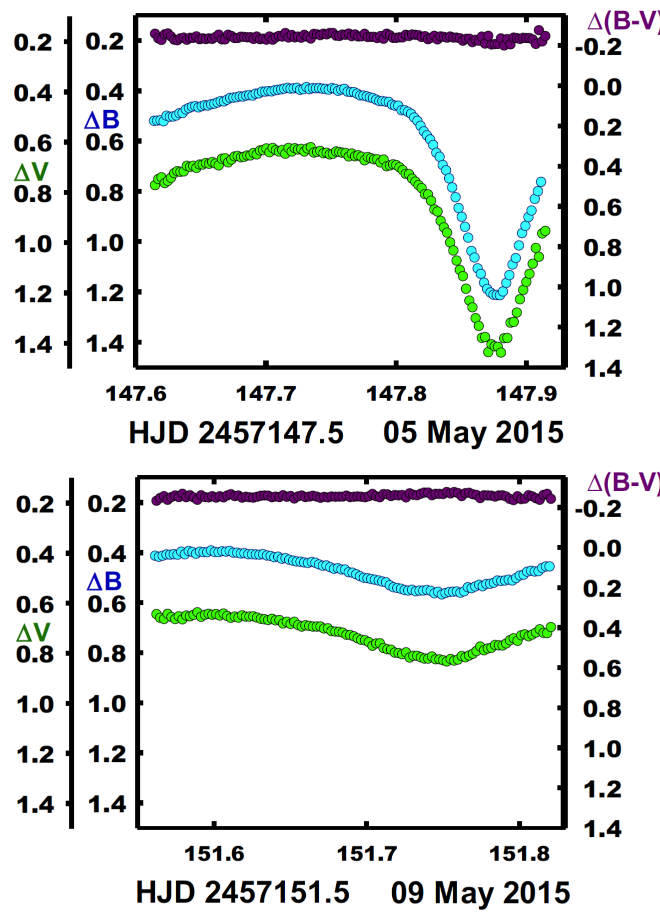

Figure 3a (top), 3b (bottom). Sample TYC 1488-693-1 observations of B, V, and B–V color curves on the nights of 5 and 9 May 2015.

Figures 3a and 3b show sample observations of B, V, and B–V color curves on the night of 5 and 9 May 2015. Our observations are given in Table 2, in delta magnitudes, ΔB, ΔV, ΔR$_c$, and ΔI$_c$, in the sense of variable minus comparison star.

4. Period study

Six mean times of minimum light were calculated, two primary and four secondary eclipses, from our present B,V,R$_c$,I$_c$ observations:

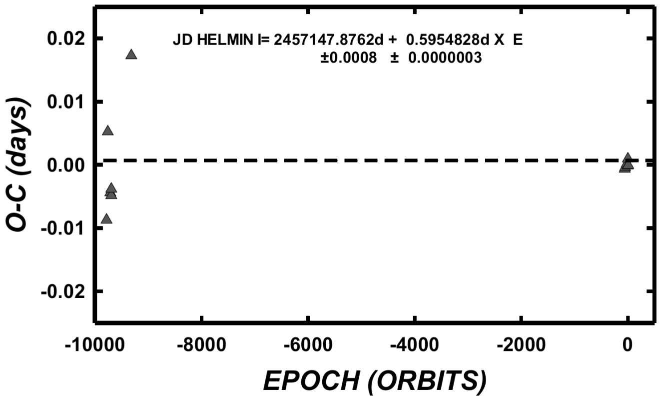

Figure 4a. Linear residuals of equation 1, TYC 1488-693-1; the residual r.m.s. = 0.0215.

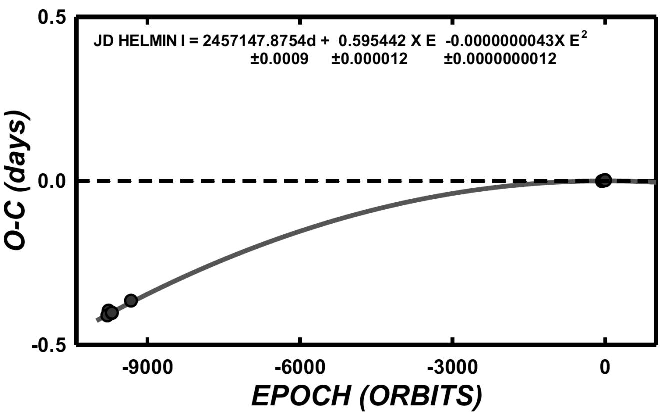

Figure 4b. Residuals of equation 2 vs. quadratic term, TYC 1488-693-1; the residual r.m.s. = 0.0120.

HJD I = 2457113.93303 ± 0.00020, 2457147.87606 ± 0.000010
HJD II = 2457117.80391 ± 0.00049, 2457136.85995 ± 0.00068, 2457148.77040 ± 0.00037, 2457151.7468 ± 0.0002

Six times of low light were taken from an earlier light curve phased from data (NSVS 10541123; Los Alamos Natl. Lab. 2017) in the Northern Sky Variability Survey. Figure 1 was used to get times of minima within ± 0.01 phase unit.

A linear ephemeris and quadratic ephemerides were determined from these data and are given next. The given errors are standard errors.

$$\mathrm{JDHelMinI} = 2457147.8762 + 0.5954828\,\mathrm{d} \times E \quad (1)$$
$$\pm 0.0008 \quad \pm 0.0000003$$

$$\mathrm{JDHelMinI} = 2457147.87539\,\mathrm{d} + 0.595442 \times E - 0.0000000043 \times E^2 \quad (2)$$
$$\pm 0.00089 \quad \pm 0.000012 \quad \pm 0.0000000012$$

The period study covers a period of some 16 years and shows a period that is decreasing. The problem with this fit is the large gap of time (nearly 9 years) between the last of the Skydot points and the first point of the present observations. So this result cannot be taken as definitive. The rate of orbital period change, $dP/dt = -5.2\,(1.5) \times 10^{-6}$ d/yr, is high for detached systems, according to my unpublished study of some 200 solar type binaries which appear at the 2018 IAU GA. The residuals from the linear and quadratic period study are given in Table 3. These residuals are plotted in Figures 4a and 4b, respectively.

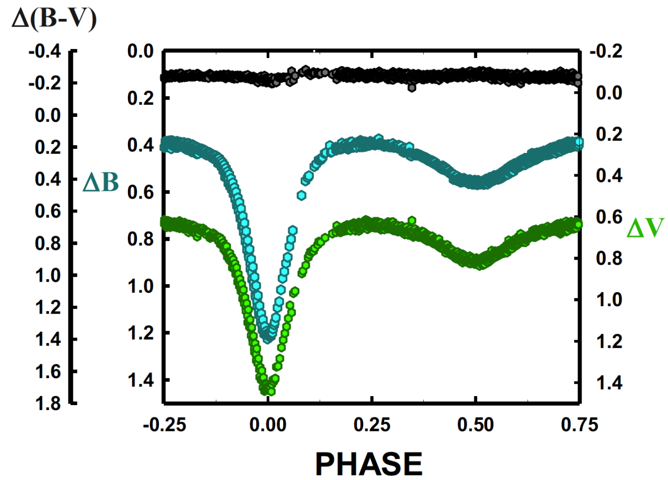

Figure 5a. ΔB, ΔV light and Δ(B–V) color curves folded using Equation (1) of TYC 1488-693-1, delta mag vs. phase.

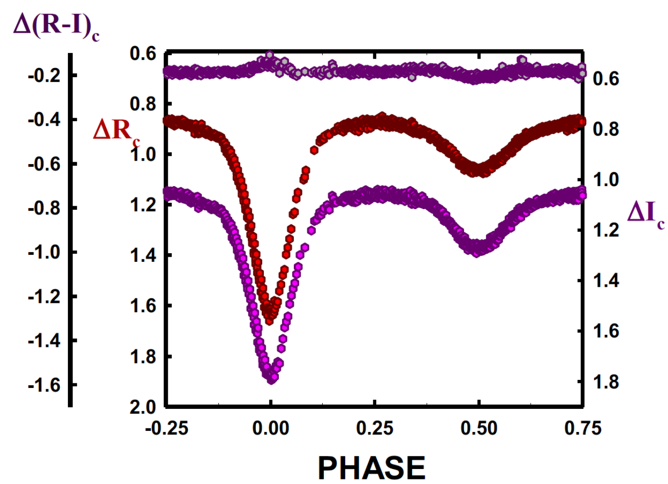

Figure 5b. ΔRc, ΔI_c light curves and $\Delta(R–I)_c$ color curves folded using equation (1) of TYC 1488-693-1, delta mag vs phase.

5. Light curve characteristics

The phased B,V and R_c,I_c light curves folded using Equation (1), delta mag vs. phase, are shown in Figures 5a and 5b, respectively. Light curve characteristics are tabulated by quadrature (averaged magnitudes about Phase 0.0, 0.25, 0.50, and 0.75) in Table 4. As noted in the table, averaged data about phase 0.0 (primary eclipse) are denoted as "Min I", phase 0.5 (secondary eclipse) as "Min II", phase 0.25 as "Max I", and phase 0.25 as "Max II". The folded light curves are of good precision, averaging somewhat better than 1% photometric precision. The primary amplitude of the light curve varies from 0.81–0.71 mag in B to I_c, indicating a substantial inclination. The secondary amplitude varies from 0.17 to 0.22 mag B to I_c, respectively. The O'Connell effect, an indicator of spot activity visible during Max I and Max II, is nearly 0.0 mag for all filters. This, however, does not preclude the possibility of other spot(s). In this case we found that a hot spot located on the primary star facing its binary partner was necessary to achieve the best fit.

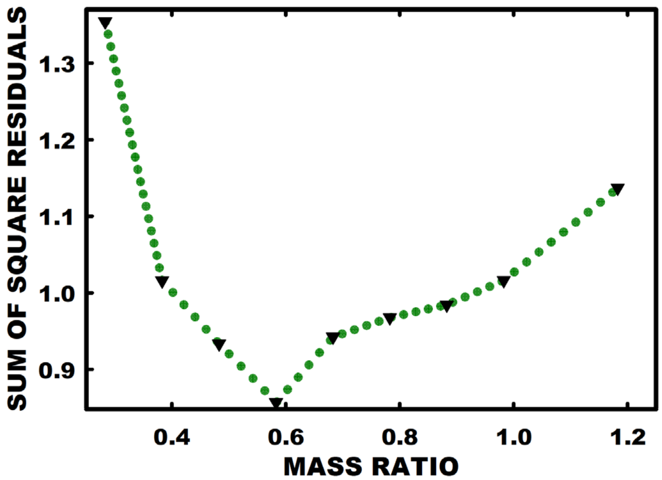

Figure 6. Various solutions at different fixed mass ratios (0.3 to 1.2) vs. the sum of square residuals of each, indicated by inverted triangles. The lowest sum of sum of square residuals occurred at mass ratio was at q ~ 0.6. This chart may be helpful in limiting a mass ratio to model when radial velocities become available.

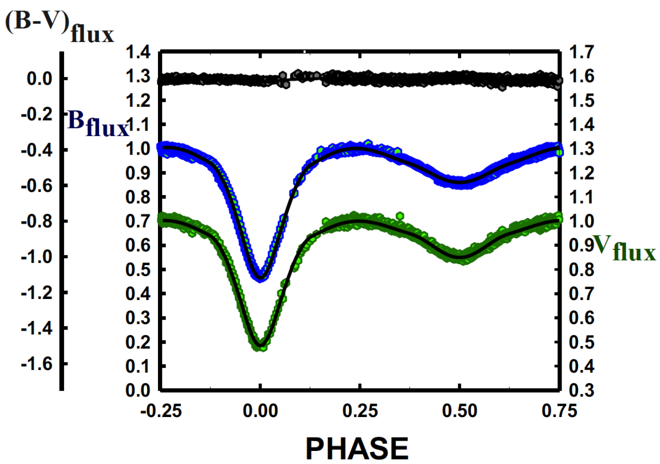

Figure 7a. Solution overlaying B, V normalized flux light curves for TYC 1488-693-1.

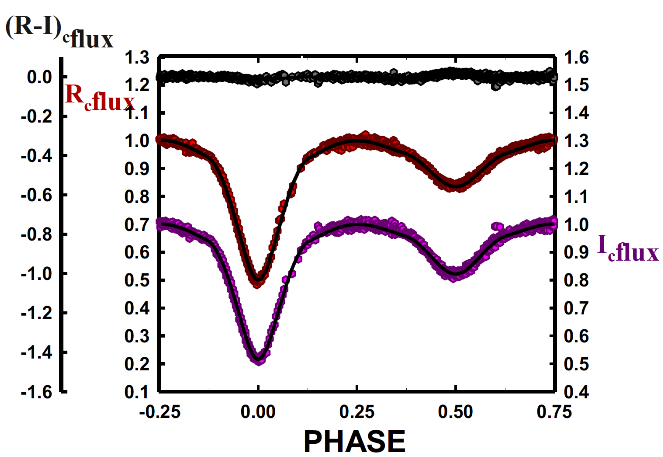

Figure 7b. Solution overlaying R_c, I_c normalized flux light curves for TYC 1488-693-1.

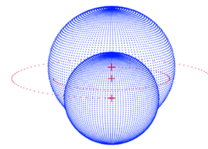

Figure 8a. Roche lobe stellar surface at phase 0.00 of TYC 1488-693-1.

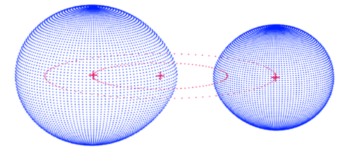

Figure 8b. Roche lobe stellar surface at phase 0.25 of TYC 1488-693-1.

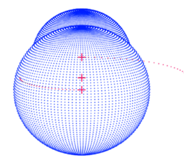

Figure 8c. Roche lobe stellar surface at phase 0.50 of TYC 1488-693-1.

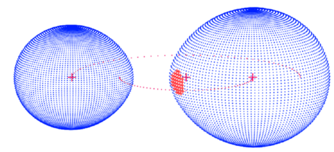

Figure 8d. Roche lobe stellar surface at phase 0.75 of TYC 1488-693-1.

The absence of the spot affects the shoulders of the curves, especially the ingress of the primary eclipse.

The differences in minima are large, 0.50–0.65 mag in I_c to B, respectively, indicating noncontact components. The fact is easily seen in the R_c–I_c color curves rising at phase zero and dipping at the secondary eclipse. This is a sign of a near contact system, Algol type.

6. Temperature and light curve solution

The *Tycho* photometry (Høg *et al.* 2000) gives a B–V = 0.409 ± 0.153 (T ~ 6600 K) and the 2MASS (*Skrutskie et al. 2006)* J–K = 0.18 ± 0.04 (T ~ 6885 K) for the binary. This corresponds to ~F2V ± 2, or a temperature of about 6750 ± 150 K. Fast rotating binary stars of this type are noted for still having magnetic activity (Samec *et al.* 2007), but this phenomena should not dominate. This binary may be becoming an early type W UMa binary.

The B, V, R_c, and I_c curves were pre-modeled with BINARY MAKER 3.0 (Bradstreet and Steelman 2002) and fits were determined in all filter bands. The result of the best fit was that of a detached eclipsing binary with both components underfilling filling their critical Roche lobes. The parameters were then averaged and input into a four-color simultaneous light curve calculation using the Wilson-Devinney Program (Wilson and Devinney 1971; Wilson 1990, 1994; Van Hamme and Wilson 1998). The solution was computed in Mode 2 so that each potential was allowed to adjust and thus the configuration was completely determined by the calculation. The solution converged in a detached configuration with a q ~ 0.58. Convective parameters, g = 0.32, A = 0.5 were used. Since the eclipses were not total, a number of solutions were generated with fixed mass ratios (q). These were iterated with spot parameters.

The sum of square residuals was tabulated with a q-value from 0.3 to 1.2. As in many cases, the original solution was found to have the lowest sum of square residuals with a q = 0.58. The mass ratio vs. residual plot is shown graphically in Figure 6. The best solution is given in Table 5. The normalized curves overlain by our light curve solutions are shown as Figure 7a, and 7b. A geometrical (Roche-lobe) representation of the system is given in Figure 8 a,b,c,d at light curve quadrature's so that the reader may see the placement of the spot and the relative size of the stars as compared to the orbit. We note here that a mass ratio search is generally not sufficient to determine the mass ratio. But it is attempted here to offer some constraint to the system's characteristics. Along this line, I note that an anonymous referee stated that a number of well fit unspotted solutions were found with mass ratios between 0.4 and 0.7.

A precision radial velocity curve is needed to find the true mass ratio.

7. Discussion

TYC 1488-693-1 is found to be a detached, near contact binary. Both Roche lobes are over 90% filled, potential-wise. The photometric spectral type indicates a surface temperature of 6750 K for the primary component. The secondary component has a temperature of ~4570 K (K4V). Our mass ratio is ~0.6, with an amplitude of 0.8–0.7 mag in B to I_c, respectively. The spot on the primary component is at the physical position that a stream spot would be expected, so it is possible that a weak plasma stream is being emitted from the secondary component with the primary component as the gainer. The inclination is 79°, which allows only 2% of the light of the system to be contributed by the secondary component at phase 0.5. The iterated hot spot region has a 9° radius and a mean T-factor of 1.05 (T ~ 7100 K). The mass ratio and the component temperatures indicate that the secondary is somewhat oversized so that interactions may have occurred in the past.

8. Conclusions

The period study of this near contact binary has a 16-year duration. But it is sparse. The orbital period was found to be decreasing. This decrease is not unusual for a typical W UMa system undergoing magnetic braking. The composite (8 nights) light curve's higher noise level as compared to that of single nights' curves may indicate solar type activity. If this is the case, the system will come into contact and then slowly coalesce over time as it loses angular momentum due to ion winds moving radially outward on stiff magnetic field lines rotating with the binary (out to the Alfvén radius). We expect the system is tending to become a W UMa contact binary and, ultimately, will become a rather normal, fast rotating, single ~A2V type field star following a red novae coalescence event when both components merge (Tylenda and Kamiński 2015).

Radial velocity curves are needed to obtain absolute (not relative) system parameters and a firm mass ratio.

9. Acknowledgements

Dr. Samec wishes to thank Dark Sky Observatory for continued use of the 32-inch observing facilities of Appalachian State University. This work has made use of data from the European Space Agency (ESA) mission Gaia (https://www.cosmos.esa.int/gaia), processed by the Gaia Data Processing and Analysis Consortium (DPAC, https://www.cosmos.esa.int/web/gaia/dpac/consortium). Funding for the DPAC has been provided by national institutions, in particular the institutions participating in the Gaia Multilateral Agreement.

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Table 2. TYC 1488-693-1 observations, ΔB, ΔV, $ΔR_c$, and $ΔI_c$, variable star minus comparison star.

ΔB	*HJD 2457000+*	*ΔB*	*HJD 2457000+*	*ΔB*	*HJD 2457000+*	*ΔB*	*HJD 2457000+*	*ΔB*	*HJD 2457000+*
0.436	113.7145	0.499	113.8712	0.552	117.8033	0.417	136.6614	0.515	136.8202
0.437	113.7169	0.513	113.8736	0.551	117.8056	0.418	136.6638	0.522	136.8227
0.437	113.7193	0.525	113.8760	0.553	117.8077	0.417	136.6663	0.525	136.8251
0.434	113.7218	0.543	113.8785	0.557	117.8099	0.414	136.6687	0.526	136.8276
0.435	113.7242	0.561	113.8809	0.555	117.8121	0.408	136.6712	0.538	136.8300
0.431	113.7266	0.582	113.8833	0.556	117.8143	0.408	136.6736	0.533	136.8324
0.432	113.7290	0.600	113.8857	0.551	117.8165	0.407	136.6760	0.542	136.8349
0.426	113.7314	0.625	113.8881	0.553	117.8186	0.405	136.6785	0.542	136.8373
0.428	113.7338	0.645	113.8905	0.547	117.8208	0.404	136.6809	0.548	136.8398
0.422	113.7362	0.671	113.8929	0.538	117.8230	0.403	136.6834	0.542	136.8422
0.421	113.7387	0.703	113.8953	0.540	117.8252	0.401	136.6858	0.550	136.8446
0.413	113.7411	0.732	113.8977	0.539	117.8274	0.393	136.6883	0.552	136.8471
0.416	113.7435	0.767	113.9001	0.537	117.8296	0.393	136.6907	0.557	136.8495
0.412	113.7459	0.806	113.9025	0.537	117.8317	0.393	136.6932	0.560	136.8520
0.415	113.7483	0.844	113.9050	0.535	117.8339	0.384	136.6956	0.562	136.8544
0.405	113.7508	0.886	113.9074	0.531	117.8361	0.386	136.6981	0.567	136.8568
0.400	113.7532	0.919	113.9098	0.531	117.8383	0.387	136.7005	0.560	136.8593
0.398	113.7556	0.962	113.9122	0.522	117.8405	0.389	136.7030	0.564	136.8617
0.399	113.7580	0.999	113.9146	0.516	117.8426	0.391	136.7055	0.561	136.8642
0.394	113.7604	1.041	113.9170	0.512	117.8448	0.390	136.7079	0.559	136.8666
0.391	113.7628	1.084	113.9194	0.502	117.8470	0.388	136.7104	0.559	136.8690
0.387	113.7653	1.118	113.9218	0.496	117.8492	0.393	136.7128	0.556	136.8715
0.387	113.7677	1.144	113.9242	0.493	117.8514	0.392	136.7153	0.545	136.8739
0.390	113.7701	1.173	113.9267	0.487	117.8535	0.395	136.7177	0.548	136.8764
0.387	113.7725	1.193	113.9291	0.487	117.8557	0.396	136.7202	0.543	136.8788
0.389	113.7749	1.202	113.9315	0.480	117.8579	0.392	136.7226	0.541	136.8812
0.388	113.7773	1.202	113.9339	0.487	117.8601	0.396	136.7250	0.544	136.8837
0.387	113.7797	1.200	113.9363	0.475	117.8623	0.401	136.7275	0.540	136.8861
0.386	113.7821	1.183	113.9387	0.478	117.8644	0.400	136.7299	0.533	136.8886
0.384	113.7845	1.155	113.9411	0.475	117.8666	0.402	136.7324	0.540	136.8910
0.385	113.7869	0.450	117.7269	0.475	117.8688	0.403	136.7348	0.530	136.8934
0.383	113.7893	0.452	117.7291	0.469	117.8710	0.403	136.7373	0.527	136.8959
0.382	113.7917	0.454	117.7313	0.472	117.8732	0.406	136.7397	0.523	136.8983
0.382	113.7942	0.460	117.7335	0.458	117.8754	0.404	136.7422	0.524	136.9008
0.386	113.7966	0.463	117.7357	0.461	117.8775	0.406	136.7446	0.515	136.9032
0.387	113.7990	0.466	117.7379	0.452	117.8797	0.409	136.7471	0.512	136.9057
0.385	113.8014	0.475	117.7400	0.455	117.8819	0.414	136.7495	0.499	136.9081
0.388	113.8038	0.475	117.7422	0.451	117.8841	0.418	136.7520	0.499	136.9105
0.389	113.8062	0.474	117.7444	0.452	117.8863	0.423	136.7544	0.503	136.9130
0.391	113.8086	0.483	117.7466	0.449	117.8884	0.431	136.7569	0.492	136.9154
0.390	113.8110	0.487	117.7488	0.445	117.8906	0.429	136.7593	0.490	136.9179
0.396	113.8134	0.491	117.7509	0.441	117.8928	0.432	136.7617	0.521	147.6143
0.393	113.8158	0.491	117.7531	0.443	117.8950	0.435	136.7641	0.520	147.6167
0.394	113.8182	0.489	117.7553	0.442	117.8972	0.441	136.7666	0.519	147.6192
0.400	113.8206	0.494	117.7575	0.432	117.8993	0.437	136.7690	0.523	147.6216
0.399	113.8231	0.498	117.7597	0.432	117.9015	0.442	136.7715	0.501	147.6240
0.403	113.8255	0.504	117.7618	0.426	117.9037	0.438	136.7739	0.505	147.6265
0.409	113.8279	0.509	117.7640	0.425	117.9059	0.443	136.7764	0.504	147.6289
0.410	113.8303	0.518	117.7662	0.423	117.9081	0.446	136.7788	0.500	147.6314
0.416	113.8327	0.521	117.7684	0.416	117.9103	0.445	136.7812	0.491	147.6338
0.416	113.8351	0.529	117.7706	0.412	117.9124	0.450	136.7837	0.490	147.6362
0.418	113.8375	0.536	117.7728	0.409	117.9146	0.455	136.7861	0.476	147.6387
0.421	113.8399	0.534	117.7749	0.412	117.9168	0.459	136.7885	0.470	147.6411
0.425	113.8423	0.544	117.7771	0.412	117.9190	0.460	136.7910	0.465	147.6435
0.431	113.8447	0.542	117.7793	0.405	117.9211	0.465	136.7934	0.463	147.6460
0.432	113.8471	0.542	117.7815	0.409	117.9233	0.466	136.7959	0.468	147.6484
0.436	113.8495	0.545	117.7837	0.409	117.9255	0.476	136.7983	0.463	147.6509
0.442	113.8519	0.547	117.7858	0.413	117.9277	0.482	136.8007	0.459	147.6533
0.444	113.8544	0.546	117.7880	0.411	117.9299	0.486	136.8032	0.460	147.6557
0.446	113.8568	0.551	117.7902	0.412	117.9320	0.489	136.8056	0.455	147.6582
0.453	113.8592	0.549	117.7924	0.413	117.9342	0.493	136.8081	0.453	147.6606
0.457	113.8616	0.548	117.7946	0.410	117.9364	0.497	136.8105	0.448	147.6631
0.467	113.8640	0.554	117.7968	0.410	117.9386	0.503	136.8129	0.443	147.6655
0.475	113.8664	0.553	117.7990	0.399	117.9408	0.500	136.8154	0.444	147.6679
0.485	113.8688	0.550	117.8011	0.422	136.6590	0.506	136.8178	0.437	147.6704

Table continued on following pages

Table 2. TYC 1488-693-1 observations, ΔB, ΔV, $ΔR_c$, and $ΔI_c$, variable star minus comparison star, cont.

ΔB	HJD 2457000+	ΔB	HJD 2457000+	ΔB	HJD 2457000+	ΔB	HJD 2457000+	ΔB	HJD 2457000+
0.430	147.6728	0.648	147.8311	0.517	148.8130	0.438	150.6635	0.409	151.6275
0.429	147.6753	0.664	147.8336	0.510	148.8154	0.435	150.6660	0.410	151.6299
0.427	147.6777	0.697	147.8360	0.507	148.8179	0.431	150.6684	0.408	151.6323
0.424	147.6801	0.718	147.8385	0.501	148.8203	0.435	150.6709	0.413	151.6348
0.425	147.6826	0.750	147.8409	0.496	148.8227	0.427	150.6733	0.415	151.6372
0.421	147.6850	0.786	147.8433	0.497	148.8252	0.427	150.6758	0.420	151.6397
0.419	147.6874	0.825	147.8458	0.494	148.8276	0.426	150.6782	0.418	151.6421
0.421	147.6899	0.868	147.8482	0.487	148.8300	0.419	150.6806	0.426	151.6445
0.413	147.6923	0.903	147.8506	0.488	148.8325	0.419	150.6830	0.424	151.6470
0.412	147.6947	0.943	147.8531	0.487	148.8349	0.413	150.6855	0.430	151.6494
0.405	147.6972	0.986	147.8555	0.484	148.8373	0.410	150.6879	0.434	151.6519
0.405	147.6996	1.039	147.8580	0.480	148.8398	0.406	150.6904	0.437	151.6543
0.403	147.7021	1.065	147.8604	0.476	148.8422	0.408	150.6928	0.438	151.6568
0.404	147.7045	1.108	147.8628	0.475	148.8446	0.407	150.6952	0.441	151.6592
0.400	147.7069	1.130	147.8653	0.467	148.8470	0.404	150.6977	0.443	151.6616
0.398	147.7094	1.165	147.8677	0.460	148.8495	0.404	150.7001	0.439	151.6641
0.396	147.7118	1.190	147.8701	0.459	148.8519	0.406	150.7025	0.442	151.6665
0.393	147.7142	1.204	147.8726	0.457	148.8543	0.411	150.7050	0.449	151.6689
0.390	147.7167	1.213	147.8750	0.455	148.8568	0.408	150.7074	0.454	151.6714
0.393	147.7191	1.214	147.8774	0.455	148.8592	0.408	150.7098	0.453	151.6738
0.392	147.7215	1.215	147.8799	0.448	148.8616	0.410	150.7122	0.460	151.6763
0.390	147.7240	1.200	147.8823	0.448	148.8641	0.416	150.7147	0.466	151.6787
0.398	147.7264	1.166	147.8848	0.441	148.8665	0.404	150.7171	0.464	151.6812
0.395	147.7289	1.135	147.8872	0.440	148.8689	0.407	150.7195	0.469	151.6836
0.387	147.7313	1.093	147.8896	0.441	148.8714	0.411	150.7220	0.469	151.6860
0.395	147.7337	1.067	147.8921	0.435	148.8738	0.410	150.7244	0.480	151.6884
0.391	147.7362	1.017	147.8945	0.439	148.8762	0.406	150.7268	0.482	151.6909
0.392	147.7386	0.968	147.8969	0.433	148.8787	0.406	150.7292	0.488	151.6933
0.391	147.7410	0.939	147.8994	0.432	148.8811	0.409	150.7317	0.496	151.6958
0.393	147.7435	0.904	147.9018	0.425	148.8835	0.412	150.7341	0.502	151.6982
0.394	147.7459	0.878	147.9042	0.426	148.8860	0.419	150.7365	0.504	151.7007
0.397	147.7484	0.832	147.9067	0.426	148.8884	0.420	150.7390	0.507	151.7031
0.391	147.7508	0.801	147.9091	0.546	150.5831	0.421	150.7414	0.510	151.7055
0.394	147.7532	0.764	147.9115	0.544	150.5855	0.429	150.7438	0.513	151.7080
0.402	147.7556	0.547	148.7377	0.546	150.5879	0.429	150.7463	0.517	151.7104
0.397	147.7581	0.547	148.7401	0.544	150.5904	0.433	150.7487	0.520	151.7128
0.394	147.7605	0.551	148.7425	0.541	150.5928	0.438	150.7511	0.532	151.7153
0.405	147.7630	0.552	148.7449	0.536	150.5953	0.437	150.7536	0.540	151.7177
0.407	147.7654	0.558	148.7474	0.531	150.5977	0.414	151.5616	0.543	151.7202
0.407	147.7678	0.557	148.7498	0.527	150.6001	0.418	151.5641	0.546	151.7226
0.413	147.7703	0.556	148.7522	0.525	150.6026	0.414	151.5665	0.551	151.7250
0.420	147.7727	0.556	148.7547	0.517	150.6050	0.409	151.5690	0.553	151.7274
0.421	147.7751	0.556	148.7571	0.512	150.6074	0.410	151.5714	0.550	151.7299
0.424	147.7776	0.565	148.7595	0.513	150.6099	0.408	151.5738	0.556	151.7323
0.428	147.7800	0.563	148.7620	0.501	150.6123	0.410	151.5762	0.553	151.7348
0.431	147.7824	0.567	148.7644	0.499	150.6148	0.398	151.5787	0.553	151.7372
0.437	147.7849	0.563	148.7668	0.494	150.6172	0.408	151.5811	0.551	151.7396
0.442	147.7873	0.567	148.7693	0.491	150.6196	0.395	151.5836	0.554	151.7421
0.443	147.7897	0.565	148.7717	0.486	150.6221	0.399	151.5860	0.564	151.7445
0.445	147.7922	0.567	148.7741	0.484	150.6245	0.406	151.5884	0.558	151.7469
0.446	147.7946	0.566	148.7766	0.484	150.6270	0.398	151.5909	0.569	151.7494
0.457	147.7971	0.566	148.7790	0.476	150.6294	0.400	151.5933	0.563	151.7518
0.461	147.7995	0.568	148.7814	0.475	150.6319	0.400	151.5957	0.559	151.7542
0.461	147.8019	0.564	148.7839	0.473	150.6343	0.393	151.5982	0.558	151.7567
0.479	147.8044	0.567	148.7863	0.468	150.6367	0.399	151.6006	0.557	151.7591
0.479	147.8068	0.560	148.7887	0.463	150.6392	0.400	151.6031	0.562	151.7615
0.485	147.8092	0.557	148.7912	0.463	150.6416	0.396	151.6055	0.556	151.7640
0.493	147.8117	0.553	148.7936	0.460	150.6440	0.398	151.6079	0.540	151.7664
0.508	147.8141	0.550	148.7960	0.453	150.6465	0.395	151.6104	0.544	151.7688
0.521	147.8165	0.541	148.7984	0.446	150.6489	0.402	151.6128	0.537	151.7713
0.541	147.8190	0.543	148.8009	0.446	150.6514	0.402	151.6153	0.530	151.7737
0.563	147.8214	0.537	148.8033	0.442	150.6538	0.405	151.6177	0.536	151.7761
0.579	147.8238	0.533	148.8057	0.442	150.6562	0.404	151.6201	0.527	151.7785
0.595	147.8263	0.526	148.8082	0.442	150.6587	0.408	151.6226	0.526	151.7810
0.617	147.8287	0.517	148.8106	0.440	150.6611	0.408	151.6250	0.522	151.7834

Table continued on following pages

Table 2. TYC 1488-693-1 observations, ΔB, ΔV, ΔR_c, and ΔI_c, variable star minus comparison star.

ΔB	*HJD 2457000+*	*ΔB*	*HJD 2457000+*	*ΔB*	*HJD 2457000+*	*ΔB*	*HJD 2457000+*	*ΔB*	*HJD 2457000+*
0.513	151.7858	0.590	152.5883	1.226	152.6395	0.412	792.9044	0.394	792.9636
0.515	151.7883	0.610	152.5907	1.215	152.6419	0.392	792.9075	0.406	792.9679
0.513	151.7907	0.631	152.5932	1.208	152.6444	0.403	792.9104	0.402	792.9726
0.510	151.7931	0.659	152.5956	0.615	792.8495	0.400	792.9120	0.398	792.9742
0.513	151.7956	0.680	152.5980	0.553	792.8552	0.396	792.9136	0.397	792.9789
0.503	151.7980	0.714	152.6005	0.539	792.8586	0.393	792.9177	0.394	792.9805
0.493	151.8004	0.746	152.6029	0.531	792.8602	0.388	792.9193	0.410	792.9860
0.490	151.8029	0.772	152.6053	0.492	792.8679	0.387	792.9221	0.406	792.9876
0.478	151.8053	0.812	152.6078	0.481	792.8708	0.391	792.9283	0.401	792.9892
0.474	151.8078	0.848	152.6102	0.464	792.8740	0.391	792.9299	0.405	792.9923
0.477	151.8102	0.879	152.6127	0.465	792.8766	0.381	792.9341	0.419	792.9939
0.476	151.8126	0.929	152.6151	0.459	792.8783	0.408	792.9374	0.430	792.9955
0.463	151.8151	0.973	152.6175	0.453	792.8799	0.405	792.9423	0.414	792.9984
0.457	151.8175	1.007	152.6200	0.436	792.8828	0.403	792.9438	0.422	793.0015
0.457	151.8199	1.047	152.6224	0.433	792.8845	0.402	792.9467	0.409	793.0043
0.494	152.5736	1.090	152.6249	0.403	792.8902	0.385	792.9483	0.446	793.0059
0.511	152.5761	1.125	152.6273	0.431	792.8918	0.392	792.9499	0.447	793.0075
0.537	152.5785	1.156	152.6297	0.429	792.8934	0.386	792.9551		
0.540	152.5810	1.188	152.6322	0.410	792.8986	0.389	792.9567		
0.564	152.5834	1.205	152.6346	0.415	792.9002	0.374	792.9604		
0.577	152.5858	1.210	152.6371	0.409	792.9018	0.392	792.9620		

ΔV	*HJD 2457000+*	*ΔV*	*HJD 2457000+*	*ΔV*	*HJD 2457000+*	*ΔV*	*HJD 2457000+*	*ΔV*	*HJD 2457000+*
0.667	113.7154	0.628	113.8119	1.134	113.9082	0.793	117.7823	0.713	117.8696
0.663	113.7178	0.634	113.8143	1.175	113.9106	0.805	117.7845	0.705	117.8718
0.661	113.7202	0.637	113.8167	1.211	113.9130	0.799	117.7866	0.707	117.8740
0.666	113.7226	0.637	113.8191	1.236	113.9154	0.807	117.7888	0.704	117.8761
0.664	113.7250	0.644	113.8215	1.284	113.9179	0.803	117.7910	0.697	117.8783
0.658	113.7274	0.641	113.8239	1.326	113.9203	0.802	117.7932	0.696	117.8805
0.656	113.7298	0.645	113.8263	1.342	113.9227	0.799	117.7954	0.689	117.8827
0.667	113.7323	0.661	113.8287	1.376	113.9251	0.812	117.7975	0.692	117.8849
0.654	113.7347	0.657	113.8311	1.405	113.9275	0.814	117.7997	0.691	117.8870
0.647	113.7371	0.655	113.8335	1.423	113.9299	0.806	117.8019	0.693	117.8892
0.655	113.7395	0.658	113.8359	1.432	113.9323	0.807	117.8041	0.692	117.8914
0.653	113.7419	0.656	113.8383	1.422	113.9347	0.809	117.8063	0.684	117.8936
0.650	113.7444	0.664	113.8408	1.408	113.9371	0.809	117.8085	0.669	117.8958
0.646	113.7468	0.672	113.8432	1.395	113.9395	0.813	117.8107	0.685	117.8979
0.639	113.7492	0.675	113.8456	1.380	113.9419	0.806	117.8129	0.681	117.9001
0.634	113.7516	0.691	113.8480	0.691	117.7277	0.804	117.8151	0.674	117.9023
0.644	113.7540	0.690	113.8504	0.687	117.7299	0.803	117.8173	0.666	117.9045
0.634	113.7564	0.679	113.8528	0.695	117.7321	0.803	117.8194	0.664	117.9067
0.635	113.7589	0.686	113.8552	0.691	117.7343	0.798	117.8216	0.671	117.9089
0.628	113.7613	0.697	113.8576	0.697	117.7365	0.795	117.8238	0.664	117.9110
0.622	113.7637	0.698	113.8600	0.710	117.7386	0.793	117.8260	0.658	117.9132
0.633	113.7661	0.700	113.8624	0.711	117.7408	0.789	117.8282	0.668	117.9154
0.627	113.7685	0.709	113.8649	0.713	117.7430	0.788	117.8303	0.662	117.9176
0.623	113.7709	0.725	113.8673	0.713	117.7452	0.781	117.8325	0.661	117.9198
0.627	113.7733	0.738	113.8697	0.715	117.7474	0.780	117.8347	0.666	117.9219
0.627	113.7757	0.743	113.8721	0.725	117.7495	0.784	117.8369	0.666	117.9241
0.623	113.7782	0.771	113.8745	0.739	117.7517	0.772	117.8391	0.682	117.9241
0.629	113.7806	0.776	113.8769	0.731	117.7539	0.767	117.8412	0.670	117.9263
0.615	113.7830	0.794	113.8793	0.740	117.7561	0.756	117.8434	0.668	117.9285
0.620	113.7854	0.807	113.8817	0.742	117.7583	0.754	117.8456	0.667	117.9307
0.619	113.7878	0.826	113.8841	0.736	117.7605	0.743	117.8478	0.671	117.9328
0.622	113.7902	0.845	113.8865	0.751	117.7626	0.742	117.8500	0.667	117.9350
0.625	113.7926	0.876	113.8889	0.760	117.7648	0.745	117.8521	0.654	117.9372
0.631	113.7950	0.901	113.8914	0.764	117.7670	0.741	117.8543	0.653	117.9394
0.625	113.7974	0.925	113.8938	0.768	117.7692	0.728	117.8565	0.658	117.9416
0.629	113.7998	0.952	113.8962	0.777	117.7714	0.728	117.8587	0.643	136.6598
0.629	113.8022	0.990	113.8986	0.781	117.7736	0.729	117.8609	0.663	136.6622
0.620	113.8046	1.018	113.9010	0.778	117.7757	0.718	117.8630	0.657	136.6647
0.626	113.8071	1.048	113.9034	0.787	117.7779	0.717	117.8652	0.657	136.6671
0.629	113.8095	1.096	113.9058	0.794	117.7801	0.714	117.8674	0.648	136.6696

Table continued on following pages

Table 2. TYC 1488-693-1 observations, ΔB, ΔV, ΔR_c, and ΔI_c, variable star minus comparison star, cont.

ΔV	HJD 2457000+	ΔV	HJD 2457000+	ΔV	HJD 2457000+	ΔV	HJD 2457000+	ΔV	HJD 2457000+
0.648	136.6720	0.773	136.8309	0.661	147.6785	0.945	147.8369	0.745	148.8187
0.639	136.6745	0.770	136.8333	0.666	147.6810	0.966	147.8393	0.736	148.8212
0.645	136.6769	0.779	136.8357	0.664	147.6834	1.005	147.8417	0.727	148.8236
0.638	136.6793	0.787	136.8382	0.659	147.6859	1.037	147.8442	0.727	148.8260
0.638	136.6818	0.781	136.8406	0.659	147.6883	1.077	147.8466	0.715	148.8285
0.630	136.6842	0.787	136.8430	0.649	147.6907	1.114	147.8491	0.717	148.8309
0.633	136.6867	0.794	136.8455	0.655	147.6931	1.139	147.8515	0.719	148.8333
0.638	136.6891	0.801	136.8479	0.639	147.6956	1.189	147.8539	0.722	148.8358
0.627	136.6916	0.790	136.8504	0.637	147.6980	1.236	147.8564	0.716	148.8382
0.630	136.6940	0.804	136.8528	0.631	147.7005	1.263	147.8588	0.712	148.8406
0.632	136.6965	0.800	136.8553	0.646	147.7029	1.306	147.8612	0.710	148.8430
0.626	136.6990	0.810	136.8577	0.629	147.7054	1.337	147.8637	0.700	148.8455
0.615	136.7014	0.799	136.8601	0.638	147.7078	1.384	147.8661	0.696	148.8479
0.618	136.7039	0.808	136.8626	0.643	147.7102	1.381	147.8685	0.694	148.8503
0.624	136.7063	0.805	136.8650	0.637	147.7127	1.441	147.8710	0.697	148.8528
0.628	136.7088	0.803	136.8674	0.652	147.7151	1.410	147.8734	0.685	148.8552
0.631	136.7112	0.793	136.8699	0.629	147.7175	1.418	147.8759	0.685	148.8576
0.624	136.7137	0.789	136.8723	0.643	147.7200	1.420	147.8783	0.684	148.8601
0.624	136.7161	0.786	136.8748	0.630	147.7224	1.443	147.8807	0.679	148.8625
0.624	136.7186	0.782	136.8772	0.635	147.7248	1.386	147.8832	0.680	148.8649
0.628	136.7210	0.779	136.8797	0.633	147.7273	1.385	147.8856	0.690	148.8674
0.629	136.7234	0.763	136.8821	0.643	147.7297	1.324	147.8880	0.665	148.8698
0.639	136.7259	0.778	136.8846	0.631	147.7321	1.321	147.8905	0.670	148.8722
0.644	136.7283	0.766	136.8870	0.626	147.7346	1.284	147.8929	0.658	148.8746
0.633	136.7308	0.772	136.8894	0.647	147.7370	1.231	147.8953	0.668	148.8771
0.625	136.7332	0.764	136.8919	0.645	147.7395	1.194	147.8978	0.662	148.8795
0.627	136.7357	0.765	136.8943	0.641	147.7419	1.162	147.9002	0.650	148.8819
0.626	136.7381	0.761	136.8967	0.650	147.7443	1.130	147.9026	0.670	148.8844
0.625	136.7406	0.754	136.8992	0.648	147.7468	1.090	147.9051	0.657	148.8868
0.638	136.7430	0.754	136.9016	0.655	147.7492	1.027	147.9075	0.659	148.8892
0.645	136.7455	0.735	136.9041	0.652	147.7516	1.062	147.9099	0.676	148.8917
0.643	136.7479	0.713	136.9065	0.643	147.7541	0.969	147.9124	0.664	148.8941
0.653	136.7504	0.726	136.9090	0.645	147.7565	0.959	147.9148	0.664	148.8965
0.644	136.7528	0.720	136.9114	0.648	147.7589	0.800	148.7409	0.658	148.8990
0.653	136.7552	0.712	136.9138	0.649	147.7614	0.798	148.7434	0.642	148.9014
0.655	136.7577	0.707	136.9163	0.663	147.7638	0.795	148.7458	0.645	148.9038
0.650	136.7601	0.714	136.9187	0.651	147.7662	0.806	148.7482	0.647	148.9063
0.663	136.7626	0.693	136.9211	0.662	147.7687	0.801	148.7506	0.640	148.9087
0.662	136.7650	0.682	136.9236	0.658	147.7711	0.804	148.7531	0.657	148.9111
0.669	136.7675	0.777	147.6151	0.664	147.7736	0.813	148.7555	0.654	148.9136
0.668	136.7699	0.753	147.6176	0.678	147.7760	0.814	148.7579	0.626	148.9160
0.659	136.7723	0.746	147.6200	0.665	147.7784	0.809	148.7604	0.766	150.5839
0.670	136.7748	0.769	147.6225	0.670	147.7809	0.817	148.7628	0.768	150.5863
0.674	136.7772	0.760	147.6249	0.674	147.7833	0.815	148.7652	0.772	150.5888
0.678	136.7796	0.748	147.6273	0.674	147.7857	0.820	148.7677	0.761	150.5912
0.670	136.7821	0.729	147.6298	0.687	147.7882	0.816	148.7701	0.774	150.5937
0.673	136.7845	0.721	147.6322	0.675	147.7906	0.814	148.7726	0.776	150.5961
0.685	136.7870	0.724	147.6346	0.702	147.7930	0.821	148.7750	0.758	150.5986
0.685	136.7894	0.722	147.6371	0.698	147.7955	0.824	148.7774	0.773	150.6010
0.699	136.7918	0.700	147.6395	0.694	147.7979	0.819	148.7799	0.753	150.6034
0.704	136.7943	0.704	147.6420	0.697	147.8003	0.824	148.7823	0.748	150.6059
0.694	136.7967	0.700	147.6444	0.706	147.8028	0.815	148.7847	0.739	150.6083
0.706	136.7991	0.708	147.6468	0.717	147.8052	0.805	148.7872	0.733	150.6107
0.708	136.8016	0.695	147.6493	0.732	147.8076	0.804	148.7896	0.741	150.6132
0.719	136.8040	0.695	147.6517	0.733	147.8101	0.798	148.7920	0.726	150.6156
0.708	136.8065	0.689	147.6541	0.751	147.8125	0.801	148.7944	0.718	150.6181
0.728	136.8089	0.692	147.6566	0.763	147.8150	0.795	148.7969	0.721	150.6205
0.734	136.8113	0.685	147.6590	0.777	147.8174	0.779	148.7993	0.704	150.6229
0.739	136.8138	0.691	147.6615	0.789	147.8198	0.783	148.8017	0.712	150.6254
0.743	136.8162	0.698	147.6639	0.813	147.8223	0.774	148.8042	0.711	150.6278
0.736	136.8186	0.672	147.6664	0.814	147.8247	0.771	148.8066	0.704	150.6303
0.750	136.8211	0.670	147.6688	0.839	147.8271	0.770	148.8090	0.694	150.6327
0.757	136.8235	0.686	147.6712	0.874	147.8296	0.764	148.8114	0.697	150.6351
0.762	136.8260	0.675	147.6737	0.882	147.8320	0.752	148.8139	0.696	150.6376
0.773	136.8284	0.663	147.6761	0.919	147.8344	0.751	148.8163	0.691	150.6400

Table continued on following pages

Table 2. TYC 1488-693-1 observations, ΔB, ΔV, $ΔR_c$, and $ΔI_c$, variable star minus comparison star.

ΔV	*HJD 2457000+*	*ΔV*	*HJD 2457000+*	*ΔV*	*HJD 2457000+*	*ΔV*	*HJD 2457000+*	*ΔV*	*HJD 2457000+*
0.688	150.6425	0.667	151.5674	0.730	151.6869	0.736	151.8062	0.701	792.8834
0.685	150.6449	0.646	151.5698	0.731	151.6893	0.729	151.8086	0.681	792.8939
0.669	150.6473	0.659	151.5722	0.736	151.6918	0.721	151.8110	0.675	792.8991
0.674	150.6498	0.667	151.5747	0.744	151.6942	0.708	151.8135	0.675	792.9048
0.673	150.6522	0.656	151.5771	0.750	151.6966	0.722	151.8159	0.674	792.9064
0.669	150.6546	0.668	151.5795	0.752	151.6991	0.723	151.8183	0.670	792.9081
0.663	150.6571	0.653	151.5820	0.759	151.7015	0.699	151.8208	0.668	792.9109
0.668	150.6595	0.656	151.5844	0.774	151.7039	0.738	152.5745	0.658	792.9125
0.675	150.6620	0.650	151.5868	0.765	151.7064	0.757	152.5769	0.666	792.9141
0.666	150.6644	0.640	151.5893	0.764	151.7088	0.767	152.5794	0.664	792.9166
0.669	150.6668	0.658	151.5917	0.783	151.7112	0.793	152.5818	0.654	792.9182
0.667	150.6693	0.650	151.5942	0.788	151.7137	0.805	152.5843	0.650	792.9225
0.658	150.6717	0.646	151.5966	0.790	151.7161	0.815	152.5867	0.847	792.9229
0.665	150.6741	0.650	151.5990	0.801	151.7186	0.846	152.5891	0.649	792.9241
0.657	150.6766	0.647	151.6015	0.803	151.7210	0.844	152.5916	0.655	792.9288
0.651	150.6790	0.653	151.6039	0.808	151.7234	0.877	152.5940	0.643	792.9304
0.647	150.6815	0.645	151.6064	0.800	151.7259	0.914	152.5965	0.657	792.9320
0.649	150.6839	0.655	151.6088	0.821	151.7283	0.934	152.5989	0.651	792.9347
0.647	150.6863	0.662	151.6112	0.814	151.7307	0.959	152.6013	0.653	792.9363
0.642	150.6888	0.657	151.6137	0.814	151.7332	0.996	152.6038	0.653	792.9427
0.644	150.6912	0.661	151.6161	0.820	151.7356	1.019	152.6062	0.660	792.9443
0.636	150.6936	0.652	151.6185	0.825	151.7380	1.055	152.6086	0.637	792.9472
0.636	150.6961	0.657	151.6210	0.825	151.7405	1.110	152.6111	0.648	792.9488
0.643	150.6985	0.657	151.6234	0.817	151.7429	1.131	152.6135	0.647	792.9504
0.639	150.7010	0.656	151.6259	0.828	151.7453	1.173	152.6160	0.652	792.9540
0.637	150.7034	0.661	151.6283	0.828	151.7478	1.207	152.6184	0.643	792.9556
0.636	150.7058	0.666	151.6308	0.832	151.7502	1.253	152.6208	0.645	792.9572
0.650	150.7082	0.668	151.6332	0.837	151.7526	1.293	152.6233	0.652	792.9609
0.645	150.7107	0.671	151.6356	0.827	151.7551	1.306	152.6257	0.640	792.9625
0.650	150.7131	0.666	151.6381	0.833	151.7575	1.373	152.6282	0.644	792.9700
0.645	150.7155	0.672	151.6405	0.829	151.7599	1.388	152.6306	0.655	792.9731
0.647	150.7180	0.671	151.6430	0.815	151.7624	1.424	152.6330	0.646	792.9747
0.645	150.7204	0.685	151.6454	0.820	151.7648	1.435	152.6355	0.657	792.9794
0.651	150.7228	0.678	151.6478	0.813	151.7672	1.432	152.6379	0.665	792.9810
0.645	150.7252	0.687	151.6503	0.806	151.7697	1.435	152.6404	0.665	792.9826
0.643	150.7277	0.678	151.6527	0.795	151.7721	1.435	152.6428	0.665	792.9881
0.641	150.7301	0.691	151.6552	0.777	151.7745	1.402	152.6452	0.846	792.9884
0.658	150.7325	0.697	151.6576	0.792	151.7770	0.874	792.8500	0.669	792.9897
0.653	150.7350	0.692	151.6600	0.785	151.7794	0.861	792.8516	0.673	792.9928
0.657	150.7374	0.694	151.6625	0.782	151.7818	0.834	792.8557	0.672	792.9960
0.675	150.7398	0.697	151.6649	0.771	151.7842	0.796	792.8591	0.672	792.9988
0.664	150.7422	0.697	151.6674	0.772	151.7867	0.783	792.8607	0.677	793.0004
0.668	150.7447	0.697	151.6698	0.773	151.7891	0.768	792.8623	0.682	793.0020
0.673	150.7471	0.705	151.6722	0.765	151.7915	0.766	792.8652	0.658	793.0064
0.682	150.7495	0.704	151.6747	0.752	151.7940	0.766	792.8668	0.618	793.0080
0.696	150.7520	0.715	151.6771	0.744	151.7964	0.752	792.8683		
0.680	150.7544	0.717	151.6796	0.754	151.7989	0.735	792.8729		
0.647	151.5625	0.718	151.6820	0.732	151.8013	0.719	792.8745		
0.662	151.5649	0.721	151.6844	0.728	151.8037	0.722	792.8772		

Table continued on following pages

Table 2. TYC 1488-693-1 observations, ΔB, ΔV, ΔR_c, and ΔI_c, variable star minus comparison star, cont.

ΔR_c	HJD 2457000+	ΔR_c	HJD 2457000+	ΔR_c	HJD 2457000+	ΔR_c	HJD 2457000+	ΔR_c	HJD 2457000+
0.908	113.7157	0.981	113.8724	1.056	117.8066	0.911	136.6651	1.002	136.8239
0.907	113.7181	0.991	113.8748	1.055	117.8088	0.899	136.6675	1.012	136.8263
0.896	113.7206	1.011	113.8772	1.054	117.8110	0.891	136.6699	1.010	136.8288
0.904	113.7230	1.021	113.8797	1.057	117.8132	0.889	136.6724	1.024	136.8312
0.901	113.7254	1.043	113.8821	1.062	117.8154	0.893	136.6748	1.030	136.8336
0.899	113.7278	1.062	113.8845	1.054	117.8175	0.886	136.6772	1.027	136.8361
0.898	113.7302	1.086	113.8869	1.048	117.8197	0.881	136.6797	1.036	136.8385
0.898	113.7326	1.105	113.8893	1.042	117.8219	0.888	136.6821	1.036	136.8410
0.885	113.7350	1.129	113.8917	1.037	117.8241	0.878	136.6846	1.041	136.8434
0.890	113.7375	1.158	113.8941	1.035	117.8263	0.885	136.6870	1.050	136.8459
0.885	113.7399	1.187	113.8965	1.037	117.8285	0.875	136.6895	1.054	136.8483
0.882	113.7423	1.225	113.8989	1.033	117.8306	0.878	136.6920	1.055	136.8507
0.886	113.7447	1.247	113.9013	1.023	117.8328	0.873	136.6944	1.054	136.8532
0.881	113.7471	1.282	113.9037	1.017	117.8350	0.867	136.6969	1.062	136.8556
0.883	113.7495	1.325	113.9062	1.009	117.8372	0.861	136.6993	1.062	136.8580
0.883	113.7520	1.354	113.9086	1.007	117.8394	0.866	136.7018	1.056	136.8605
0.876	113.7544	1.396	113.9110	1.007	117.8415	0.865	136.7042	1.053	136.8629
0.870	113.7568	1.427	113.9134	0.998	117.8437	0.864	136.7067	1.049	136.8654
0.872	113.7592	1.471	113.9158	0.986	117.8459	0.873	136.7091	1.062	136.8678
0.868	113.7616	1.496	113.9182	0.979	117.8481	0.871	136.7116	1.044	136.8703
0.862	113.7640	1.530	113.9206	0.973	117.8503	0.876	136.7140	1.045	136.8727
0.863	113.7664	1.562	113.9230	0.968	117.8524	0.873	136.7165	1.036	136.8751
0.862	113.7689	1.590	113.9254	0.962	117.8546	0.865	136.7189	1.032	136.8776
0.861	113.7713	1.614	113.9279	0.957	117.8568	0.861	136.7214	1.019	136.8800
0.865	113.7737	1.620	113.9302	0.955	117.8590	0.865	136.7238	1.023	136.8825
0.858	113.7761	1.630	113.9327	0.956	117.8612	0.868	136.7263	1.022	136.8849
0.866	113.7785	1.622	113.9351	0.950	117.8633	0.876	136.7287	1.017	136.8873
0.864	113.7809	1.613	113.9375	0.942	117.8655	0.876	136.7311	1.020	136.8898
0.865	113.7833	1.598	113.9399	0.945	117.8677	0.876	136.7336	1.013	136.8922
0.862	113.7857	0.914	117.7280	0.934	117.8699	0.878	136.7360	1.006	136.8947
0.870	113.7881	0.924	117.7302	0.932	117.8721	0.876	136.7385	0.989	136.8971
0.861	113.7905	0.916	117.7324	0.926	117.8743	0.872	136.7409	0.998	136.8995
0.870	113.7929	0.925	117.7346	0.922	117.8764	0.881	136.7434	0.983	136.9020
0.871	113.7954	0.929	117.7368	0.912	117.8786	0.877	136.7458	0.974	136.9044
0.866	113.7978	0.935	117.7389	0.919	117.8808	0.882	136.7483	0.965	136.9069
0.866	113.8002	0.932	117.7411	0.918	117.8830	0.879	136.7507	0.961	136.9093
0.869	113.8026	0.936	117.7433	0.919	117.8852	0.892	136.7532	0.964	136.9118
0.863	113.8050	0.946	117.7455	0.914	117.8873	0.883	136.7556	0.938	136.9142
0.867	113.8074	0.955	117.7477	0.907	117.8895	0.895	136.7581	0.953	136.9166
0.879	113.8098	0.955	117.7498	0.909	117.8917	0.884	136.7605	0.938	136.9191
0.876	113.8122	0.958	117.7520	0.913	117.8939	0.900	136.7629	0.931	136.9215
0.880	113.8146	0.957	117.7542	0.908	117.8961	0.899	136.7654	0.948	136.9239
0.880	113.8170	0.966	117.7564	0.906	117.8982	0.900	136.7678	0.914	136.9264
0.882	113.8194	0.971	117.7586	0.908	117.9004	0.897	136.7702	0.990	147.6155
0.890	113.8218	0.972	117.7607	0.906	117.9026	0.901	136.7727	0.994	147.6179
0.881	113.8242	0.987	117.7629	0.898	117.9048	0.900	136.7751	0.987	147.6204
0.894	113.8267	0.983	117.7651	0.900	117.9070	0.908	136.7776	0.980	147.6228
0.894	113.8291	0.998	117.7673	0.901	117.9091	0.904	136.7800	0.977	147.6253
0.891	113.8315	0.998	117.7695	0.890	117.9113	0.909	136.7824	0.965	147.6277
0.897	113.8339	1.013	117.7717	0.886	117.9135	0.913	136.7849	0.949	147.6301
0.909	113.8363	1.022	117.7738	0.889	117.9157	0.914	136.7873	0.948	147.6326
0.904	113.8387	1.023	117.7760	0.892	117.9179	0.927	136.7897	0.943	147.6350
0.904	113.8411	1.034	117.7782	0.890	117.9200	0.924	136.7922	0.942	147.6374
0.913	113.8435	1.038	117.7804	0.890	117.9222	0.922	136.7946	0.940	147.6399
0.917	113.8459	1.034	117.7826	0.888	117.9244	0.939	136.7971	0.932	147.6423
0.921	113.8483	1.042	117.7847	0.898	117.9266	0.943	136.7995	0.930	147.6447
0.919	113.8507	1.052	117.7869	0.908	117.9288	0.944	136.8019	0.917	147.6472
0.923	113.8531	1.043	117.7891	0.899	117.9310	0.949	136.8044	0.928	147.6496
0.931	113.8556	1.050	117.7913	0.895	117.9331	0.968	136.8068	0.920	147.6521
0.929	113.8580	1.047	117.7935	0.897	117.9353	0.961	136.8093	0.920	147.6545
0.932	113.8604	1.048	117.7957	0.901	117.9375	0.967	136.8117	0.914	147.6569
0.948	113.8628	1.057	117.7978	0.894	117.9397	0.975	136.8141	0.907	147.6594
0.952	113.8652	1.058	117.8000	0.894	117.9419	0.976	136.8166	0.911	147.6618
0.962	113.8676	1.057	117.8022	0.904	136.6602	0.988	136.8190	0.916	147.6643
0.983	113.8700	1.063	117.8044	0.897	136.6626	0.990	136.8215	0.900	147.6667

Table continued on following pages

Table 2. TYC 1488-693-1 observations, ΔB, ΔV, $ΔR_c$, and $ΔI_c$, variable star minus comparison star, cont.

$ΔR_c$	*HJD 2457000+*	$ΔR_c$	*HJD 2457000+*	$ΔR_c$	*HJD 2457000+*	$ΔR_c$	*HJD 2457000+*	$ΔR_c$	*HJD 2457000+*
0.891	147.6692	1.072	147.8275	0.980	148.8118	0.924	150.6355	0.883	151.5994
0.897	147.6716	1.107	147.8299	0.990	148.8142	0.923	150.6379	0.881	151.6018
0.890	147.6740	1.119	147.8323	0.968	148.8167	0.913	150.6404	0.883	151.6043
0.889	147.6765	1.138	147.8348	0.962	148.8191	0.911	150.6428	0.888	151.6067
0.892	147.6789	1.178	147.8372	0.963	148.8215	0.907	150.6452	0.880	151.6091
0.890	147.6813	1.203	147.8397	0.945	148.8239	0.904	150.6477	0.885	151.6116
0.888	147.6838	1.226	147.8421	0.940	148.8264	0.900	150.6501	0.891	151.6140
0.884	147.6862	1.256	147.8445	0.949	148.8288	0.898	150.6526	0.881	151.6164
0.888	147.6886	1.292	147.8470	0.946	148.8312	0.902	150.6550	0.893	151.6189
0.880	147.6911	1.334	147.8494	0.946	148.8337	0.900	150.6574	0.887	151.6213
0.885	147.6935	1.387	147.8519	0.935	148.8361	0.899	150.6599	0.891	151.6238
0.876	147.6959	1.418	147.8543	0.939	148.8385	0.897	150.6623	0.888	151.6262
0.871	147.6984	1.448	147.8567	0.930	148.8410	0.896	150.6647	0.892	151.6287
0.874	147.7008	1.486	147.8592	0.927	148.8434	0.884	150.6672	0.886	151.6311
0.876	147.7033	1.515	147.8616	0.928	148.8458	0.897	150.6696	0.897	151.6335
0.875	147.7057	1.549	147.8640	0.922	148.8482	0.894	150.6721	0.899	151.6360
0.865	147.7081	1.577	147.8665	0.915	148.8507	0.885	150.6745	0.893	151.6384
0.870	147.7106	1.611	147.8689	0.902	148.8531	0.886	150.6769	0.893	151.6409
0.863	147.7130	1.609	147.8713	0.914	148.8555	0.884	150.6794	0.900	151.6433
0.865	147.7154	1.614	147.8738	0.907	148.8580	0.884	150.6818	0.896	151.6458
0.866	147.7179	1.613	147.8762	0.901	148.8604	0.882	150.6842	0.908	151.6482
0.871	147.7203	1.620	147.8786	0.898	148.8628	0.870	150.6867	0.907	151.6506
0.868	147.7227	1.626	147.8811	0.896	148.8653	0.872	150.6891	0.916	151.6531
0.870	147.7252	1.591	147.8835	0.899	148.8677	0.873	150.6916	0.914	151.6555
0.866	147.7276	1.584	147.8860	0.901	148.8701	0.877	150.6940	0.917	151.6580
0.874	147.7301	1.542	147.8884	0.892	148.8726	0.872	150.6964	0.915	151.6604
0.870	147.7325	1.516	147.8908	0.898	148.8750	0.872	150.6989	0.921	151.6628
0.861	147.7349	1.479	147.8933	0.896	148.8774	0.878	150.7013	0.918	151.6653
0.867	147.7374	1.457	147.8957	0.884	148.8799	0.872	150.7037	0.917	151.6677
0.873	147.7398	1.397	147.8981	0.883	148.8823	0.872	150.7062	0.919	151.6701
0.868	147.7422	1.369	147.9005	0.889	148.8847	0.875	150.7086	0.921	151.6726
0.866	147.7447	1.335	147.9030	0.876	148.8872	0.879	150.7110	0.923	151.6750
0.871	147.7471	1.296	147.9054	0.883	148.8896	0.874	150.7134	0.941	151.6775
0.876	147.7495	1.238	147.9079	0.876	148.8920	0.887	150.7159	0.938	151.6799
0.880	147.7520	1.229	147.9103	0.878	148.8945	0.883	150.7183	0.938	151.6823
0.880	147.7544	1.176	147.9127	0.886	148.8969	0.879	150.7207	0.943	151.6848
0.888	147.7569	1.151	147.9151	0.900	148.8993	0.872	150.7232	0.954	151.6872
0.885	147.7593	1.032	148.7437	0.893	148.9018	0.883	150.7256	0.955	151.6897
0.890	147.7617	1.034	148.7461	0.871	148.9042	0.881	150.7280	0.973	151.6921
0.890	147.7642	1.035	148.7486	0.865	148.9066	0.886	150.7305	0.966	151.6945
0.889	147.7666	1.045	148.7510	0.881	148.9091	0.891	150.7329	0.977	151.6970
0.896	147.7690	1.047	148.7534	0.865	148.9115	0.887	150.7353	0.983	151.6994
0.895	147.7715	1.055	148.7559	0.866	148.9139	0.891	150.7378	0.985	151.7018
0.889	147.7739	1.055	148.7583	0.876	148.9164	0.894	150.7402	0.996	151.7043
0.911	147.7764	1.059	148.7607	1.028	150.5843	0.898	150.7426	0.994	151.7067
0.902	147.7788	1.051	148.7632	1.007	150.5867	0.918	150.7450	1.001	151.7092
0.911	147.7812	1.054	148.7656	1.028	150.5891	0.903	150.7475	1.017	151.7116
0.921	147.7837	1.058	148.7680	1.005	150.5916	0.918	150.7499	1.018	151.7140
0.918	147.7861	1.055	148.7705	1.004	150.5940	0.917	150.7523	1.023	151.7165
0.912	147.7885	1.058	148.7729	1.000	150.5965	0.881	150.7548	1.043	151.7189
0.929	147.7910	1.063	148.7753	0.984	150.5989	0.879	151.5628	1.041	151.7214
0.922	147.7934	1.060	148.7778	0.982	150.6013	0.897	151.5653	1.047	151.7238
0.928	147.7958	1.063	148.7802	0.986	150.6038	0.890	151.5677	1.062	151.7262
0.934	147.7983	1.056	148.7826	0.980	150.6062	0.906	151.5702	1.055	151.7287
0.936	147.8007	1.056	148.7851	0.974	150.6086	0.897	151.5726	1.063	151.7311
0.936	147.8031	1.045	148.7875	0.960	150.6111	0.910	151.5750	1.064	151.7335
0.938	147.8056	1.034	148.7899	0.958	150.6135	0.895	151.5775	1.073	151.7360
0.955	147.8080	1.034	148.7924	0.950	150.6160	0.896	151.5799	1.074	151.7384
0.968	147.8104	1.041	148.7948	0.941	150.6184	0.879	151.5823	1.059	151.7408
0.976	147.8129	1.029	148.7972	0.938	150.6209	0.892	151.5848	1.071	151.7433
0.981	147.8153	1.023	148.7997	0.940	150.6233	0.900	151.5872	1.068	151.7457
1.000	147.8177	1.014	148.8021	0.935	150.6257	0.878	151.5896	1.067	151.7481
1.014	147.8202	1.010	148.8045	0.931	150.6282	0.896	151.5921	1.071	151.7506
1.036	147.8226	1.002	148.8069	0.923	150.6306	0.880	151.5945	1.076	151.7530
1.048	147.8250	0.989	148.8094	0.926	150.6330	0.877	151.5969	1.073	151.7554

Table continued on following pages

Table 2. TYC 1488-693-1 observations, ΔB, ΔV, ΔR_c, and ΔI_c, variable star minus comparison star, cont.

ΔR_c	*HJD 2457000+*	ΔR_c	*HJD 2457000+*	ΔR_c	*HJD 2457000+*	ΔR_c	*HJD 2457000+*	ΔR_c	*HJD 2457000+*
1.073	151.7579	0.927	151.8163	1.502	152.6236	0.902	792.8994	0.868	792.9628
1.060	151.7603	0.934	151.8187	1.545	152.6261	0.884	792.9052	0.871	792.9655
1.053	151.7627	0.921	151.8212	1.568	152.6285	0.882	792.9067	0.864	792.9687
1.057	151.7652	0.909	151.8236	1.606	152.6309	0.881	792.9095	0.868	792.9718
1.042	151.7676	0.980	152.5748	1.627	152.6334	0.896	792.9112	0.867	792.9734
1.041	151.7700	0.994	152.5773	1.638	152.6358	0.875	792.9128	0.860	792.9750
1.031	151.7724	1.001	152.5797	1.660	152.6383	0.880	792.9153	0.864	792.9781
1.035	151.7749	1.013	152.5822	1.640	152.6407	0.881	792.9169	0.872	792.9797
1.026	151.7773	1.032	152.5846	1.637	152.6431	0.883	792.9185	0.874	792.9813
1.020	151.7798	1.048	152.5871	1.580	152.6456	0.875	792.9212	0.871	792.9852
1.017	151.7822	1.057	152.5895	1.101	792.8487	0.872	792.9229	0.880	792.9868
1.010	151.7846	1.093	152.5919	1.090	792.8503	0.871	792.9244	0.871	792.9884
0.994	151.7871	1.110	152.5944	1.064	792.8519	0.871	792.9307	0.879	792.9915
0.986	151.7895	1.128	152.5968	0.984	792.8638	0.862	792.9333	0.877	792.9931
0.988	151.7919	1.159	152.5992	0.951	792.8716	0.874	792.9349	0.883	792.9947
0.994	151.7943	1.186	152.6017	0.940	792.8732	0.874	792.9366	0.885	792.9975
0.975	151.7968	1.220	152.6041	0.938	792.8759	0.873	792.9399	0.884	792.9991
0.964	151.7992	1.250	152.6066	0.941	792.8774	0.869	792.9475	0.886	793.0007
0.972	151.8017	1.289	152.6090	0.927	792.8790	0.867	792.9491	0.871	793.0035
0.963	151.8041	1.319	152.6114	0.919	792.8836	0.864	792.9527	0.879	793.0051
0.956	151.8065	1.353	152.6139	0.923	792.8853	0.862	792.9543	0.883	793.0067
0.948	151.8090	1.396	152.6163	0.909	792.8926	0.858	792.9559		
0.940	151.8114	1.434	152.6187	0.905	792.8951	0.868	792.9596		
0.930	151.8138	1.470	152.6212	0.891	792.8978	0.849	792.9612		

ΔI_c	*HJD 2457000+*	ΔI_c	*HJD 2457000+*	ΔI_c	*HJD 2457000+*	ΔI_c	*HJD 2457000+*	ΔI_c	*HJD 2457000+*
1.084	113.7257	1.055	113.8126	1.434	113.9017	1.202	117.7698	1.153	117.8505
1.077	113.7281	1.066	113.8150	1.464	113.9041	1.210	117.7720	1.147	117.8527
1.081	113.7306	1.065	113.8174	1.500	113.9065	1.217	117.7741	1.134	117.8549
1.076	113.7330	1.073	113.8198	1.528	113.9089	1.230	117.7763	1.133	117.8571
1.072	113.7354	1.076	113.8222	1.562	113.9113	1.232	117.7785	1.134	117.8593
1.062	113.7378	1.070	113.8246	1.588	113.9137	1.242	117.7807	1.121	117.8615
1.065	113.7402	1.068	113.8270	1.643	113.9161	1.241	117.7829	1.128	117.8636
1.056	113.7426	1.083	113.8294	1.666	113.9186	1.250	117.7850	1.114	117.8658
1.065	113.7451	1.092	113.8318	1.696	113.9210	1.250	117.7872	1.120	117.8680
1.065	113.7475	1.087	113.8342	1.714	113.9234	1.259	117.7894	1.104	117.8702
1.061	113.7499	1.093	113.8366	1.741	113.9258	1.262	117.7916	1.113	117.8724
1.062	113.7523	1.097	113.8391	1.766	113.9282	1.267	117.7938	1.091	117.8745
1.058	113.7547	1.099	113.8439	1.774	113.9306	1.261	117.7959	1.096	117.8767
1.053	113.7572	1.111	113.8463	1.769	113.9330	1.271	117.7981	1.100	117.8789
1.053	113.7596	1.104	113.8487	1.755	113.9354	1.269	117.8003	1.096	117.8811
1.048	113.7620	1.101	113.8511	1.748	113.9378	1.272	117.8025	1.093	117.8833
1.053	113.7644	1.110	113.8535	1.748	113.9402	1.265	117.8047	1.079	117.8854
1.054	113.7668	1.119	113.8559	1.098	117.7283	1.264	117.8069	1.092	117.8876
1.054	113.7692	1.118	113.8583	1.097	117.7305	1.270	117.8091	1.087	117.8898
1.049	113.7716	1.117	113.8607	1.108	117.7327	1.255	117.8113	1.089	117.8920
1.048	113.7740	1.136	113.8631	1.100	117.7349	1.269	117.8135	1.093	117.8942
1.046	113.7764	1.135	113.8656	1.111	117.7370	1.268	117.8157	1.084	117.8985
1.052	113.7788	1.147	113.8680	1.103	117.7392	1.255	117.8178	1.092	117.9007
1.052	113.7812	1.160	113.8704	1.112	117.7414	1.248	117.8200	1.083	117.9029
1.045	113.7837	1.170	113.8728	1.123	117.7436	1.245	117.8222	1.080	117.9051
1.048	113.7861	1.178	113.8752	1.126	117.7458	1.236	117.8244	1.069	117.9073
1.047	113.7885	1.195	113.8776	1.138	117.7479	1.234	117.8266	1.075	117.9094
1.049	113.7909	1.209	113.8800	1.134	117.7501	1.242	117.8288	1.057	117.9116
1.045	113.7933	1.231	113.8824	1.149	117.7523	1.223	117.8309	1.071	117.9138
1.052	113.7957	1.248	113.8848	1.153	117.7545	1.215	117.8331	1.073	117.9160
1.055	113.7981	1.268	113.8872	1.158	117.7567	1.206	117.8353	1.070	117.9182
1.052	113.8005	1.295	113.8896	1.167	117.7589	1.209	117.8375	1.078	117.9203
1.061	113.8029	1.312	113.8921	1.166	117.7610	1.202	117.8397	1.071	117.9225
1.060	113.8053	1.345	113.8945	1.179	117.7632	1.197	117.8418	1.070	117.9247
1.057	113.8077	1.367	113.8969	1.182	117.7654	1.179	117.8440	1.066	117.9269
1.056	113.8102	1.401	113.8993	1.189	117.7676	1.169	117.8484	1.069	117.9291

Table continued on following pages

Table 2. TYC 1488-693-1 observations, ΔB, ΔV, $ΔR_c$, and $ΔI_c$, variable star minus comparison star, cont.

$ΔI_c$	HJD 2457000+	$ΔI_c$	HJD 2457000+	$ΔI_c$	HJD 2457000+	$ΔI_c$	HJD 2457000+	$ΔI_c$	HJD 2457000+
1.074	117.9312	1.141	136.8121	1.099	147.6573	1.204	147.8205	1.217	148.7976
1.066	117.9334	1.160	136.8145	1.091	147.6597	1.220	147.8230	1.219	148.8000
1.074	117.9356	1.164	136.8169	1.099	147.6622	1.248	147.8254	1.213	148.8024
1.082	117.9378	1.173	136.8194	1.092	147.6646	1.263	147.8278	1.206	148.8049
1.077	117.9400	1.182	136.8218	1.085	147.6671	1.288	147.8303	1.188	148.8073
1.081	117.9421	1.190	136.8243	1.079	147.6695	1.296	147.8327	1.183	148.8097
1.085	136.6605	1.195	136.8267	1.075	147.6720	1.332	147.8351	1.175	148.8122
1.081	136.6630	1.209	136.8291	1.077	147.6744	1.352	147.8376	1.168	148.8146
1.090	136.6654	1.205	136.8316	1.076	147.6768	1.383	147.8400	1.160	148.8170
1.086	136.6678	1.221	136.8340	1.070	147.6793	1.416	147.8424	1.150	148.8194
1.073	136.6703	1.230	136.8364	1.072	147.6817	1.453	147.8449	1.137	148.8219
1.077	136.6727	1.229	136.8389	1.075	147.6841	1.475	147.8473	1.136	148.8243
1.063	136.6752	1.245	136.8413	1.074	147.6866	1.500	147.8498	1.134	148.8267
1.067	136.6776	1.250	136.8438	1.066	147.6890	1.546	147.8522	1.125	148.8292
1.076	136.6801	1.258	136.8462	1.063	147.6914	1.592	147.8547	1.123	148.8316
1.068	136.6825	1.261	136.8486	1.067	147.6939	1.609	147.8571	1.116	148.8340
1.070	136.6849	1.254	136.8511	1.062	147.6988	1.653	147.8595	1.126	148.8365
1.059	136.6874	1.273	136.8535	1.068	147.7012	1.687	147.8619	1.114	148.8389
1.060	136.6899	1.253	136.8560	1.056	147.7036	1.714	147.8644	1.115	148.8413
1.064	136.6923	1.258	136.8584	1.061	147.7061	1.732	147.8668	1.114	148.8438
1.054	136.6948	1.269	136.8608	1.057	147.7085	1.754	147.8693	1.104	148.8462
1.042	136.6972	1.256	136.8633	1.051	147.7109	1.772	147.8717	1.098	148.8486
1.051	136.6997	1.260	136.8657	1.048	147.7134	1.769	147.8741	1.092	148.8510
1.056	136.7021	1.260	136.8682	1.049	147.7158	1.765	147.8766	1.092	148.8535
1.053	136.7095	1.258	136.8706	1.051	147.7182	1.788	147.8790	1.091	148.8559
1.047	136.7119	1.249	136.8731	1.065	147.7231	1.781	147.8814	1.088	148.8583
1.053	136.7168	1.229	136.8755	1.051	147.7255	1.737	147.8839	1.094	148.8608
1.054	136.7193	1.231	136.8779	1.047	147.7280	1.722	147.8863	1.089	148.8632
1.051	136.7217	1.222	136.8804	1.050	147.7304	1.728	147.8887	1.081	148.8656
1.061	136.7242	1.229	136.8828	1.048	147.7329	1.669	147.8912	1.089	148.8681
1.063	136.7266	1.226	136.8853	1.060	147.7353	1.631	147.8936	1.087	148.8705
1.060	136.7291	1.219	136.8877	1.049	147.7377	1.586	147.8960	1.074	148.8729
1.067	136.7315	1.211	136.8901	1.054	147.7402	1.563	147.8985	1.090	148.8754
1.067	136.7340	1.202	136.8926	1.060	147.7426	1.542	147.9009	1.075	148.8778
1.052	136.7364	1.188	136.8950	1.060	147.7450	1.493	147.9033	1.074	148.8802
1.057	136.7388	1.189	136.8975	1.049	147.7475	1.460	147.9058	1.074	148.8827
1.059	136.7413	1.181	136.8999	1.067	147.7499	1.432	147.9082	1.086	148.8851
1.055	136.7437	1.155	136.9023	1.072	147.7523	1.410	147.9106	1.056	148.8875
1.062	136.7462	1.171	136.9048	1.067	147.7548	1.375	147.9131	1.066	148.8900
1.057	136.7486	1.140	136.9072	1.072	147.7572	1.346	147.9155	1.070	148.8924
1.060	136.7511	1.140	136.9097	1.074	147.7596	1.299	147.9180	1.060	148.8948
1.054	136.7535	1.150	136.9121	1.092	147.7621	1.218	148.7392	1.078	148.8972
1.067	136.7560	1.121	136.9145	1.081	147.7645	1.229	148.7416	1.069	148.8997
1.060	136.7584	1.112	136.9170	1.082	147.7670	1.231	148.7441	1.060	148.9021
1.064	136.7609	1.066	136.9194	1.075	147.7694	1.240	148.7465	1.068	148.9045
1.083	136.7633	1.065	136.9219	1.093	147.7718	1.251	148.7489	1.068	148.9070
1.059	136.7657	1.124	136.9243	1.083	147.7743	1.247	148.7514	1.057	148.9094
1.067	136.7682	1.068	136.9267	1.091	147.7767	1.252	148.7538	1.081	148.9118
1.074	136.7706	1.194	147.6158	1.088	147.7791	1.254	148.7562	1.056	148.9143
1.079	136.7730	1.175	147.6183	1.102	147.7816	1.259	148.7587	1.039	148.9167
1.082	136.7755	1.171	147.6207	1.103	147.7840	1.281	148.7611	1.207	150.5846
1.066	136.7779	1.178	147.6232	1.096	147.7864	1.271	148.7635	1.209	150.5871
1.077	136.7804	1.147	147.6256	1.110	147.7889	1.271	148.7660	1.185	150.5895
1.094	136.7828	1.139	147.6280	1.118	147.7913	1.273	148.7684	1.203	150.5919
1.091	136.7852	1.150	147.6305	1.116	147.7937	1.272	148.7708	1.197	150.5944
1.092	136.7877	1.138	147.6329	1.117	147.7962	1.261	148.7733	1.174	150.5968
1.093	136.7901	1.133	147.6353	1.122	147.7986	1.275	148.7757	1.179	150.5993
1.091	136.7925	1.123	147.6378	1.115	147.8011	1.266	148.7781	1.191	150.6017
1.096	136.7950	1.119	147.6402	1.132	147.8035	1.258	148.7806	1.163	150.6041
1.108	136.7974	1.113	147.6427	1.124	147.8059	1.270	148.7830	1.164	150.6066
1.123	136.7999	1.111	147.6451	1.135	147.8084	1.259	148.7854	1.143	150.6090
1.115	136.8023	1.104	147.6475	1.151	147.8108	1.257	148.7879	1.141	150.6114
1.121	136.8047	1.091	147.6500	1.162	147.8132	1.244	148.7903	1.137	150.6139
1.126	136.8072	1.092	147.6524	1.175	147.8157	1.241	148.7927	1.120	150.6163
1.140	136.8096	1.096	147.6549	1.188	147.8181	1.236	148.7952	1.126	150.6188

Table continued on next page

Table 2. TYC 1488-693-1 observations, ΔB, ΔV, $ΔR_c$, and $ΔI_c$, variable star minus comparison star, cont.

$ΔI_c$	HJD 2457000+	$ΔI_c$	HJD 2457000+	$ΔI_c$	HJD 2457000+	$ΔI_c$	HJD 2457000+	$ΔI_c$	HJD 2457000+
1.116	150.6212	1.076	150.7381	1.095	151.6656	1.205	151.7825	1.143	792.8702
1.113	150.6236	1.087	150.7405	1.098	151.6681	1.203	151.7850	1.130	792.8718
1.101	150.6261	1.089	150.7430	1.090	151.6705	1.190	151.7874	1.141	792.8735
1.107	150.6285	1.086	150.7454	1.100	151.6729	1.189	151.7898	1.127	792.8762
1.104	150.6310	1.086	150.7478	1.104	151.6754	1.177	151.7923	1.114	792.8777
1.101	150.6334	1.113	150.7503	1.109	151.6778	1.169	151.7947	1.101	792.8823
1.105	150.6358	1.101	150.7527	1.115	151.6803	1.168	151.7971	1.115	792.8839
1.098	150.6383	1.081	151.5632	1.115	151.6827	1.162	151.7996	1.120	792.8855
1.098	150.6407	1.088	151.5656	1.122	151.6851	1.151	151.8020	1.064	792.8896
1.092	150.6432	1.089	151.5681	1.133	151.6876	1.143	151.8045	1.075	792.8912
1.095	150.6456	1.090	151.5705	1.137	151.6900	1.150	151.8069	1.092	792.8929
1.082	150.6480	1.087	151.5729	1.141	151.6925	1.129	151.8093	1.091	792.8954
1.082	150.6505	1.076	151.5754	1.151	151.6949	1.127	151.8118	1.079	792.9039
1.076	150.6529	1.066	151.5778	1.164	151.6973	1.131	151.8142	1.068	792.9070
1.079	150.6553	1.068	151.5827	1.163	151.6998	1.110	151.8166	1.064	792.9099
1.082	150.6578	1.081	151.5851	1.169	151.7022	1.160	152.5752	1.063	792.9131
1.077	150.6602	1.078	151.5876	1.177	151.7047	1.180	152.5777	1.077	792.9156
1.076	150.6627	1.081	151.5900	1.186	151.7071	1.187	152.5801	1.063	792.9188
1.080	150.6651	1.073	151.5924	1.201	151.7095	1.199	152.5825	1.060	792.9215
1.074	150.6675	1.070	151.5949	1.206	151.7120	1.230	152.5850	1.062	792.9232
1.064	150.6700	1.070	151.5973	1.216	151.7144	1.242	152.5874	1.065	792.9278
1.065	150.6724	1.067	151.5997	1.231	151.7168	1.252	152.5898	1.050	792.9310
1.063	150.6749	1.074	151.6022	1.238	151.7193	1.281	152.5923	1.056	792.9337
1.065	150.6773	1.068	151.6046	1.241	151.7217	1.306	152.5947	1.048	792.9401
1.068	150.6797	1.074	151.6071	1.258	151.7241	1.317	152.5972	1.060	792.9417
1.070	150.6822	1.077	151.6095	1.263	151.7266	1.347	152.5996	1.050	792.9434
1.061	150.6846	1.066	151.6119	1.261	151.7290	1.380	152.6020	1.053	792.9462
1.062	150.6870	1.068	151.6144	1.279	151.7314	1.402	152.6045	1.054	792.9494
1.059	150.6895	1.066	151.6168	1.271	151.7339	1.433	152.6069	1.040	792.9546
1.055	150.6919	1.069	151.6192	1.270	151.7363	1.453	152.6093	1.048	792.9562
1.054	150.6944	1.065	151.6217	1.274	151.7387	1.511	152.6118	1.048	792.9599
1.056	150.6968	1.063	151.6241	1.275	151.7412	1.530	152.6142	1.042	792.9615
1.062	150.6992	1.079	151.6266	1.292	151.7436	1.575	152.6167	1.043	792.9658
1.061	150.7017	1.076	151.6290	1.277	151.7461	1.598	152.6191	1.053	792.9673
1.064	150.7041	1.081	151.6315	1.283	151.7485	1.644	152.6215	1.049	792.9720
1.068	150.7065	1.075	151.6339	1.283	151.7509	1.675	152.6240	1.042	792.9753
1.061	150.7090	1.079	151.6363	1.281	151.7534	1.681	152.6264	1.055	792.9800
1.063	150.7114	1.076	151.6388	1.268	151.7558	1.735	152.6289	1.055	792.9887
1.062	150.7138	1.085	151.6412	1.275	151.7582	1.747	152.6313	1.055	792.9918
1.062	150.7162	1.076	151.6437	1.265	151.7607	1.770	152.6337	1.057	792.9934
1.063	150.7187	1.078	151.6461	1.269	151.7631	1.775	152.6362	1.066	792.9950
1.064	150.7211	1.080	151.6486	1.258	151.7655	1.765	152.6386	1.045	793.0010
1.073	150.7235	1.097	151.6510	1.253	151.7679	1.794	152.6411	1.081	793.0038
1.062	150.7260	1.085	151.6534	1.256	151.7704	1.785	152.6435	1.053	793.0054
1.075	150.7284	1.098	151.6559	1.225	151.7728	1.269	792.8506		
1.077	150.7308	1.091	151.6583	1.238	151.7752	1.202	792.8597		
1.073	150.7333	1.092	151.6607	1.223	151.7777	1.164	792.8641		
1.083	150.7357	1.093	151.6632	1.204	151.7801	1.160	792.8673		

Table 3. Residuals from the Linear and Quadratic period study of TYC 1488-693-1.

No.	*Epochs*	*Cycles*	*Linear Residuals*	*Quadratic Residuals*	*Wt*	*Reference*
1	51322.2596	–9783.0	–0.0087	–0.0038	0.2	NSVS (Pojmański 2013)
2	51336.2674	–9759.5	0.0052	0.0092	0.2	NSVS (Pojmański 2013)
3	51364.2454	–9712.5	–0.0044	–0.0024	0.2	NSVS (Pojmański 2013)
4	51375.2614	–9694.0	–0.0048	–0.0036	0.2	NSVS (Pojmański 2013)
5	51375.2624	–9694.0	–0.0038	–0.0026	0.2	NSVS (Pojmański 2013)
6	51599.4828	–9317.5	0.0173	0.0035	0.2	NSVS (Pojmański 2013)
7	57113.9330	–57.0	–0.0007	–0.0022	1.0	Present observations
8	57117.8039	–50.5	–0.0004	–0.0017	1.0	Present observations
9	57136.8600	–18.5	0.0002	0.0002	1.0	Present observations
10	57147.8761	0.0	–0.0002	0.0007	1.0	Present observations
11	57148.7704	1.5	0.0010	0.0019	1.0	Present observations
12	57151.7468	6.5	0.0000	0.0010	1.0	Present observations

Table 4. TYC 1488-693-1, light curve characteristics.

Filter	*Phase*	*Magnitude Min. I*	*Phase*	*Magnitude Max. I*
	0.00		0.25	
ΔB		1.21 ± 0.01		0.39 ± 0.01
ΔV		1.42 ± 0.01		0.64 ± 0.01
ΔR_c		1.62 ± 0.02		0.87 ± 0.01
ΔI_c		1.77 ± 0.01		1.06 ± 0.01
Filter	*Phase*	*Magnitude Min. II*	*Phase*	*Magnitude Max. II*
	0.50		0.75	
ΔB		0.56 ± 0.01		0.40 ± 0.01
ΔV		0.81 ± 0.01		0.63 ± 0.01
ΔR_c		1.06 ± 0.02		0.87 ± 0.01
ΔI_c		1.27 ± 0.01		1.06 ± 0.01
Filter		*Min. I – Max. I*		*Max. I – Max. II*
ΔB		0.81 ± 0.01		0.00 ± 0.01
ΔV		0.78 ± 0.02		0.01 ± 0.02
ΔR_c		0.75 ± 0.02		0.00 ± 0.01
ΔI_c		0.71 ± 0.02		0.00 ± 0.02
Filter		*Min. I – Min. II*		*Min. II – Max. II*
ΔB		0.65 ± 0.02		0.17 ± 0.02
ΔV		0.61 ± 0.02		0.18 ± 0.02
ΔR		0.56 ± 0.04		0.19 ± 0.01
ΔI		0.50 ± 0.02		0.22 ± 0.02

Table 5. TYC 1488-693-1, a light curve solution.

Parameters	*Values*
λ_B, λ_V, λ_{Rc}, λ_{Ic} (nm)	440, 550, 640, 790
$x_{bol1,2}$, $y_{bol1,2}$	0.641, 0. 630, 0.232, 0.145
$x_{1Ic,2Ic}$, $y_{1Ic,2Ic}$	0. 569, 0.668, 0. 271, 0.144
$x_{1Rc,2Rc}$, $y_{1Rc,2Rc}$	0.652, 0.754, 0. 278, 0.096
$x_{1V,2V}$, $y1V,2V$	0.725, 0.799, 0. 266, 0.006
$x_{1B,2B}$, $y_{1B,2B}$	0. 815, 0.840, 0.206, –0.155
g_1, g_2	0.32
A_1, A_2	0.5
Inclination (°)	78.74 ± 0.04
T_1, T_2 (K)	6750, 4397 ± 2
Ω_1, Ω_2	3. 150 ± 0.001, 3.191 ± 0.002
$q(m_2/m_1)$	0.5829 ± 0.0007
Fill–outs: F_1, F_2	96.27 ± 0.04%, 95.03 ± 0.04%
$L_1/(L_1+L_2)_I$	0.8974 ± 0.0003
$L_1/(L_1+L_2)_R$	0.9215 ± 0.0003
$L_1/(L_1+L_2)_V$	0.9464 ± 0.0004
$L_1/(L_1+L_2)_B$	0.9720 ± 0.0003
JDo (days)	2457147.83765 ± 0.00024
Period (days)	0.5954652 ± 0. 0000015
r_1, r_2 (pole)	0. 3838 ± 0.0015, 0.288 ± 0.001
r1, r2 (point)	0.461 ± 0.004, 0.340 ± 0.003
r_1, r_2 (side)	0.403 ± 0.002, 0.298 ± 0.001
r_1, r_2 (back)	0.426 ± 0.002, 0.320 ± 0.002