First apsidal motion and light curve analysis of 162 eccentric eclipsing binaries from LMC[★]

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ABSTRACT

We present an extensive study of 162 early-type binary systems located in the LMC galaxy that show apsidal motion and have never been studied before. For the ample systems, we performed light curve and apsidal motion modelling for the first time. These systems have a median orbital period of 2.2 days and typical periods of the apsidal motion were derived to be of the order of decades. We identified two record-breaking systems. The first, OGLE LMC-ECL-22613, shows the shortest known apsidal motion period among systems with main sequence components (6.6 years); it contains a third component with an orbital period of 23 years. The second, OGLE LMC-ECL-17226, is an eccentric system with the shortest known orbital period (0.9879 days) and with quite fast apsidal motion period (11 years). Among the studied systems, 36 new triple-star candidates were identified based on the additional period variations. This represents more than 20% of all studied systems, which is in agreement with the statistics of multiples in our Galaxy. However, the fraction should only be considered as a lower limit of these early-type stars in the LMC because of our method of detection, data coverage, and limited precision of individual times of eclipses.

Key words. binaries: eclipsing – stars: fundamental parameters – stars: early-type – Magellanic Clouds

1. Introduction

The use of eclipsing binaries (EBs) for the precise derivation of the physical parameters of their components, such as masses and radii, still represents the most powerful method for deriving these quantities (see e.g. [Southworth 2012](#)). And thanks to these parameters we are able to improve and calibrate the existing models of stellar structure and evolution ([Torres et al. 2010](#)). We can also use the EBs as independent distance indicators, even outside of our Galaxy (e.g. [Hilditch et al. 2005](#) or [Vilardell et al. 2010](#)).

Moreover, the eccentric EBs with detectable apsidal motion are important objects for studies of the internal structure constants and also to test the general relativity ([Claret & Giménez 1993](#)). For the systems, where the presence of an additional third body was detected, the more interesting dynamical interactions were also studied by [Borkovits et al. \(2015\)](#), among others. A large compilation of 623 galactic eccentric EBs was presented by [Kim et al. \(2018\)](#). The authors showed that about 5% of the systems they analysed also have a third unseen component (only based on eclipse timing variations, hereafter ETV). Finally, the effects like orbital circularisation ([Zahn 2008](#)) can also be studied by means of distribution of systems in the

period-eccentricity diagram (see e.g. [Kiminki & Kobulnicky 2012](#) or [Meibom & Mathieu 2005](#)).

Several similar studies were published on this topic, focusing on the eccentric EBs in the LMC and SMC and yielding the apsidal motion parameters, but the present study is the most extensive one. The studies that use a similar method of analysing the photometry and yield the apsidal motion, and that contain three or more systems from the LMC and/or SMC, are summarised in Table 1.

2. Method of analysis

The selection of potential apsidal motion systems was a byproduct of our analysis of the whole LMC catalogue of EBs scanned for doubly eclipsing systems. We identified several hundreds of prospective eccentric systems for a more detailed analysis, but only a small part of them were found to fit our criteria. With these limitations we mainly mean the apsidal motion period, which has to be shorter than 200 years (principal limit due to a typical data coverage, see below). This was the strictest criterion because a large portion of the systems show apsidal motion but with very long periods. Other criteria were the data coverage of the light curve (LC) and its photometric amplitude (depth of minima), but also good coverage of the apsidal motion in the $O - C$ diagram, where the apsidal motion should be unambiguously detectable.

For our whole analysis we only used the photometric data. Databases like OGLE and MACHO were used when available,

[★] The time series data are only available at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via <http://cdsarc.u-strasbg.fr/viz-bin/cat/J/A+A/640/A33>

Table 1. Compilation of papers studying LMC/SMC eccentric binaries.

Paper	Field	Number of systems
Zasche & Wolf (2013)	LMC	5
Zasche et al. (2014)	SMC	18
Zasche et al. (2015)	LMC	13
Hong et al. (2015)	SMC	27
Hong et al. (2016)	SMC	90
Hong et al. (2019)	LMC	3
Zasche & Wolf (2019)	SMC	21
Our present study	LMC	162

while for some systems new photometry from the Danish 1.54 m telescope (hereafter DK154) was also obtained¹. MACHO data (Alcock et al. 1997) cover the period 1992–2000, while the OGLE experiment (Udalski et al. 1992) was run in several parts: OGLE II in 1997–2000, OGLE III 2001–2009, and OGLE IV 2010–2014 for both Magellanic Clouds. The Photometric Data Retriever PDR (Zejda et al. 2019) was used for some systems to obtain the data.

The LC analysis using the PHOEBE 0.32SVN code (Prša & Zwitter 2005) (which is based on the Wilson-Devinney algorithm Wilson & Devinney 1971) was routinely used for the analysis of all systems in our sample. However, when there was no spectroscopy, several assumptions had to be made: the mass ratio was fixed at $q = 1.0$, and the coefficients of albedo A , limb-darkening x , and gravity brightening g were kept fixed at their suggested values for hot stars. The quality of LCs does not usually allow us to also fit these second-order parameters.

A necessary input parameter is the primary temperature, which was estimated from the de-reddened photometric index $(B - V)_0$, which was derived following the procedure by Johnson (1958) using the values of photometric indices $(B - V)$ and $(U - B)$. The use of this method is substantiated because we deal here only with hot stars (of spectral types O-B-A), for which this presented $(B - V)_0$ transformation works. These values are given below in Table A.1. The primary temperature was derived from the $(B - V)_0$ photometric index using the assumption of main-sequence components and the tables by Pecaut & Mamajek (2013) and its later updates available online².

This procedure of T_1 estimation was used for majority of stars, but for 27 systems from our sample this resulted in rather dubious results. From these 27 systems, 19 systems were found with very low values of their indices $(B - V)_0 < -0.31$. Normal O-type stars should have the index in the range -0.32 to -0.31 , but here we deal with almost all systems having much lower unrealistic values of this photometric index. Therefore, we decided to skip this colour information completely. Moreover, four systems have unavailable indices from Massey (2002) and Zaritsky et al. (2002); two systems have unrealistically high values of $(B - V)_0 > 0$; and finally two systems have values of their $(B - V)_0$ indices that are too different from those of Massey (2002) and Zaritsky et al. (2002). For these 27 systems we only roughly estimated their effective temperatures from their apparent magnitudes (and this magnitude-temperature relation was constructed using the other systems with realistic $(B - V)_0$ values). These stars are flagged in Table A.1 with asterisks. Accord-

ing to this temperature estimation it seems that all of the stars have effective temperatures below 32 000 K, hence none of our stars is an O-type star.

From the complete LC analysis, we constructed an LC template, which was later used to derive the times of eclipses via our AFP method (see Zasche et al. 2014). For the sake of brevity, all the figures of the LCs given here were plotted during a shorter time interval to avoid phase smearing due to change of argument of periastron ω (and using mostly only OGLE III data in the I filter).

At this point it would be useful to explain our method step by step. First, we only roughly estimated the orbital period and the eccentricity. With this assumption, we made the LC template and performed a preliminary period analysis resulting in better estimation of the true eccentricity and the period. With these values of eccentricity and period, we constructed a better LC fit. With the new LC template we were able to perform better apsidal motion analysis. With this iterative procedure we were able to get the final solution, which is the one presented in Table A.2. It should also be mentioned that for the LC analysis we used the photometric data phased only for some shorter time interval (typically one or two OGLE seasons only, i.e. 1 or 2 years) to eliminate the effect of apsidal motion causing the change of duration and depth of the LC for the template. For systems where the apsidal motion is fast, we constructed several such templates and used them separately for certain time intervals of our photometric data. The rate of apsidal motion was derived from the eclipse times, which we found is better than that derived from the LC fits. The apsidal motion analysis uses the standard technique of least-squares minimisation, as introduced by Gimenez & Garcia-Pelayo (1983) and Giménez & Bastero (1995), among others.

3. Results

Due to the very large number of individual systems, we cannot focus on each of the stars analysed in our sample. We would thus like to focus only on the most interesting results and systems that deserve our attention, and to encourage future observers and investigators to consider these particular systems.

All of our results are divided into several parts. First, the classical LC modelling and its results are given below in Table A.2 and the plots in Figs. 1 and A.1. Second, the apsidal motion parameters are given in Table A.2, while the fits can be seen in Figs. 2 and A.2. These figures show the apparent period variations of the particular stars via the eclipse timing variation together with the fits. Finally, the systems where some additional variations in the times of eclipses were detected and showed unambiguous period variability were additionally fitted assuming the light-time effect hypothesis (Mayer 1990). This hypothesis assumes a third body orbiting the inner eccentric eclipsing binary around a common barycentre. However, the potential detectability of any such body is highly dependent on the third body's mass, its orbit, orientation, period, etc. Therefore, the number of systems detected with our method should be considered a lower limit, and any definite conclusions about the multiplicity fraction are still rather speculative because the incompleteness fraction would be rather high (see discussion in Sect. 5). Altogether 36 such systems were found for which the residuals after the apsidal motion fits were successfully fitted with the light-time effect hypothesis. All of these are shown in Figs. 3 and A.3, while five parameters of these fits are given in Table A.3.

¹ Also available online via CDS.

² www.pas.rochester.edu/~emamajek/EEM_dwarf_UBVIJHK_colors_Teff.txt

Fig. 1. Sample of plots of the light curves, full set of figures is in appendix section.

Fig. 2. Sample of plots of the $O - C$ diagrams, full set of figures is in appendix section. Final fits of the apsidal motion are plotted as black and blue curves (for primary and secondary minima), while the individual points represent the times of eclipses. The larger the symbol, the higher the weight (which was assigned according to its uncertainty). New observations with DK154 are shown in red. In cases where an additional third body was found, the final fit is plotted (solid lines) together with only the apsidal motion fits (dashed lines).

Fig. 3. Sample of plots of the $O - C$ diagrams after subtraction of apsidal motion fits. The LTE variations are plotted as red curves. Full set of figures is in appendix section.

At this point it would be useful to recall some basic equations of the light-time effect and also our analysis approach. The observed deviation of individual minima in the $O - C$ diagram can be described by

$$(O - C) = JD_i - HJD_0 - P \cdot E - (O - C)_{\text{LTE}} - (O - C)_{\text{AM}}, \quad (1)$$

where the particular minimum JD_i at epoch E is being compared with its theoretical prediction also taking into account the light-time effect term $(O - C)_{\text{LTE}}$ and the apsidal motion term

$(O - C)_{\text{AM}}$. The light-time effect can be expressed as

$$(O - C)_{\text{LTE}} = \frac{A}{\sqrt{1 - e_3^2 \cos^2 \omega_3}} \left[\frac{(1 - e_3^2) \sin(\nu + \omega_3)}{1 + e_3 \cos \nu} + e_3 \sin \omega_3 \right], \quad (2)$$

where A is the semi-amplitude, e_3 is the eccentricity of the third body orbit, ω_3 its argument of periastron, and ν its true anomaly.

The mass function of this third-body orbit can be expressed as

$$f(m_3) = \frac{(m_3 \sin i)^3}{(m_1 + m_2 + m_3)^2} = \frac{1}{P_3^2} \cdot \left[\frac{173.15 \cdot A}{\sqrt{1 - e_3^2 \cos^2 \omega_3}} \right]^3, \quad (3)$$

where i stands for the inclination between the mutual orbit and the plane of the sky, and m_1 , m_2 , m_3 are the masses of the primary, secondary, and tertiary components, respectively. For the second expression it is necessary to input the units of the outer period P_3 in years and the semi-amplitude A in days. With this mass function we can at least make some preliminary estimates about the third body's mass. However, for some more reliable derivation precise masses and also the inclination are needed. We also note that in a triple system, there is in principle a much more complicated influence of the third perturbing body on the apsidal motion of the eccentric inner pair (see e.g. Borkovits et al. 2015 or Borkovits et al. 2019) in addition to the classical tidal and the relativistic contributions.

The total ETV component due to the action of a third body is composed in principle of several contributions. Here we assume only the most dominant one, the classical geometrical light-time effect term. However, in general there are also other dynamical terms. In principle, these effects can be large or even dominate over the classical light-time effect. In our sample, where we deal with quite short orbital periods of the inner pairs and quite long periods of the outer bodies, we can state that for the majority of systems the light-time effect is certainly the dominant one. In Rappaport et al. (2013) a physical delay due to the third body is introduced, which has its amplitude proportional to the ratio (P^2/P_3). Hence, for majority of our systems third-body period that is too long makes the amplitude of this physical delay too small. On the other hand, there are also other longer-period perturbations (see e.g. Rappaport et al. 2013, Sect. 4.2), which have typical periods of the order of P_3^2/P , and that cause for example the orbital precession and change in the eclipse depths. In our sample the timescales of the longer-period perturbations are typically longer than a human lifetime. Both these ratios P^2/P_3 , and P_3^2/P are given in the last columns of Table A.3.

The question arises of whether these systems show some concordance with the systems with a detected third light contribution. However, we note that this link is not so unambiguous. For some of the potential triple systems the third bodies should have only negligibly low luminosities. On the other hand, for some systems, the detection of a third light could also be explained by an unbound star along the same line of sight. This situation is nothing novel in these very dense stellar fields in the LMC. However, mostly the detection of the light-time effect agrees with the non-zero value of the third light for a particular system. A typical example would be OGLE LMC-ECL-15664, which was identified as a system showing the largest mass function, as well as the largest value of the third light in the LC solution.

The quality of the apsidal motion fits in Figs. 2 and A.2 is mostly reasonable, but strongly depends on the value of eccentricity of the orbit (i.e. the amplitude of apsidal motion in the $O - C$ diagram), and its apsidal motion rate (i.e. the period of apsidal advance, because longer periods only have small parts covered with data). The quality of the individual times of eclipses is comparable for different systems (usually of the order of 0.001–0.0001 d), only those with shallow eclipses and/or longer orbital periods have less precise times of eclipse.

The most interesting definitely seem to be those systems with third bodies and with a very rapid apsidal motion. Stars that

Fig. 4. Histogram of orbital periods of the analysed systems.

have very fast apsidal motion usually have very short orbital periods. Among these, there was discovered a record-breaking system, OGLE LMC-ECL-17226, which has an eccentric orbit despite its short period ($P = 0.9879314$ day). This is, as far as we know, the shortest eccentric main sequence star ever discovered (the previous record of about 1.016 days belongs to the star V456 Oph located in our Galaxy; see Wolf et al. 2017). The apsidal motion of OGLE LMC-ECL-17226 is also rather fast (about 12 yr), while its eccentricity is very low (about 0.037).

Among other stars (in addition to OGLE LMC-ECL-17226), additional systems having a very rapid apsidal motion of about ten years or even faster were also found: OGLE LMC-ECL-06837 ($U = 9.9$ yr), #17774 ($U = 7.2$ yr), -22613 ($U = 6.6$ yr), -23298 ($U = 12.2$ yr), -25047 ($U = 10.8$ yr). To date, the system with the fastest apsidal advance in our Galaxy is V490 Cyg (Zasche & Wolf 2011) having $U = 18.6$ yr, while out of our Galaxy, it is the star from the SMC named OGLE SMC-ECL-2194 having $U = 7.1$ yr (Hong et al. 2015). For the list of all our analysed systems and their results, see Table A.2. It is important to note that the ephemerides given in Table A.2 are not always suitable for planning future observations. They represent only the value $O - C = 0$ in the diagrams in Figs. 2 and A.2. Hence for eclipse predictions, corrections are needed, especially in cases where the eccentricity is high and the apsidal motion amplitude significant.

Another interesting group of stars is the one where the third-body contribution to ETV caused by the light-time effect is even larger than the contribution from the apsidal motion itself. These are: OGLE LMC-ECL-10302, -16320, -17267, -20860, and -22613. The dominance of the light-time effect can be caused by two different phenomena: a very massive third body causing large amplitude of ETV, or in some systems only very low eccentricity of the inner orbit. In our cases shown here, both of these explanations play a role together.

4. Properties of the sample

First we look at the distribution of the orbital periods of the stars in our sample. Obviously, these are influenced by a strong selection effect, mainly due to our method of selection. Only those systems having an adequately short orbital period (usually $P \lesssim 3$ d) can be studied using our methods (and having enough data for such an analysis). For this reason the plot in Fig. 4 shows a vast majority of systems from 1 to 3 days. Shorter-period systems are usually circular, while the longer-period ones usually have too slow apsidal motion to show a significant change over two decades, which is the typical time span of our data.

Fig. 5. Apsidal motion period vs orbital period.

Fig. 6. Histogram of relative radii of all systems for both eclipsing components.

Another diagram in Fig. 5 shows how the apsidal motion period depends on the orbital period of the binary. Longer-period systems usually also have slower apsidal motion, while the fastest apsidal motion should preferably be detected for shorter orbital periods.

In Fig. 6 we show the distribution of the relative radii resulting from our light curve analysis (for the primary and secondary components). It is clearly seen that preferentially those systems having relative radii between 0.15 and 0.25 were usually studied. This is again a selection effect of our method. Systems having too distant components usually have too slow apsidal motion (>200 yr) to be detectable with our approach, and systems closer to each other were already circularised.

In Fig. 7 we plotted the eccentricity versus orbital period. For comparison we also added other compilations and apsidal motion studies from LMC/SMC from Table 1, and the apsidal motion systems published in the catalogue of Kim et al. (2018), who studied galactic systems. It is clearly seen that our present sample incorporates mainly the shorter-period systems (mostly below 4 days), but the overall tendency to detect the higher eccentricities only with longer periods is obvious. Hence, the circularisation in more compact systems is also much faster in the LMC galaxy (see e.g. Tassoul 1988).

5. Discussion and conclusions

Our new analysis of 162 eccentric eclipsing binaries in LMC presents the largest sample studied to date in one paper (both of the LC and apsidal motion) and provide us with unique material for comparison with other results.

Fig. 7. Distribution of eccentricities vs orbital periods for eclipsing binaries. The red dots are our new data from the present paper, which are being compared with the other LMC/SMC systems. The blue dots are taken from our previous analyses, and the cyan dots are taken from publications by Hong et al. (see table in Sect. 1 for reference). A comparison with galactic eclipsing binaries as published in the catalogue of Kim et al. (2018) are plotted in black. Circularisation in shorter periods is clearly visible here.

Because we have limited information about the stars, and no spectroscopy for these targets, the inferred parameters are only relative ones (like the relative radii), and the masses are completely unknown. The uncertainties of masses inferred from the photometric indices are too large, hence they cannot easily be used to derive the internal structure constants. Only future spectroscopic monitoring would help us in this aspect.

The ETVs due to the light-time effect term are usually rather small, which also yielded small mass function values (with only a few exceptions). The other ETV effects are negligible, or would be very slow (see the last columns of Table A.3). Hence, for instance we cannot hope to find any dynamical indication of these third bodies, for example via changing the inclination angle through eclipse depth variations (only one system has the typical period of this nodal regression below 1000 years).

On the other hand, the presented study of residuals and fitting of the light-time effect (see Figs. 3 and A.3) is only one part of the whole sample. Other systems were found to show additional variation, but they are still not well-covered, have too long periods, or too low amplitudes. For these reasons the variation is visible, but for a proper analysis we need more data spanning a longer time interval or better data to reduce the scatter. This is why we only briefly mention these systems in Figs. 8 and A.4, where the residuals after the subtraction of the apsidal motion are plotted, but no light-time effect fit is given yet. This should encourage observers to collect new data for these systems to prove or reject the hypothesis of the third body.

If we take into account the proved 36 systems with the light-time effect fits in Figs. 3 and A.3 and add the 19 suspected ones from Figs. 8 and A.4, then the total fraction of potential triples in our sample grows from 20% to about 34%. We are aware that our preprocessing and selection of suitable systems for this analysis can provide some bias towards these potential triples. However, as was already stated in Sect. 2, for most of the discarded systems the criterion was the slow rate of apsidal motion. This is probably not directly connected with the multiplicity, hence its role should be small. However, what should play a role is that the stars with very small photometric amplitude (shallow eclipses) were also neglected. These systems might also be triples because the high value of the third light makes the eclipses shallower. Hence, we

Fig. 8. Sample of plots of the $O-C$ diagrams after subtraction of apsidal motion fits for cases where there appears to be some variation of residuals, but it is still rather questionable. More data are needed. Full set of figures is in appendix section.

would probably miss these potential triples rather than overestimate their fraction in the LMC eclipsing sample. Such a large fraction of potential triples is several times more than what was found in their sample by [Kim et al. \(2018\)](#). However, they studied the stars in our Galaxy, where the field stars are of much later spectral type; hence, the multiplicity fraction is much lower ([Duchêne & Kraus 2013](#)). Therefore, our number should only be compared with the suggested number of multiples in the early-type population in LMC. According to [Duchêne & Kraus \(2013\)](#), the probability of a star to be a multiple for these massive stars should be very high and reach almost 100% for the O and B stars. Hence, our rough estimation of 1/3 should be considered a lower limit due to the methodology incompleteness limitations (e.g. long periods and short periods cannot be detected with our method; masses and inclinations play a crucial role for a light-time effect to emerge in our residuals).

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References

Alcock, C., Allsman, R. A., Alves, D., et al. 1997, *ApJ*, **486**, 697
 Borkovits, T., Rappaport, S., Hajdu, T., et al. 2015, *MNRAS*, **448**, 946
 Borkovits, T., Forgács-Dajka, E., & Rappaport, S. A. 2019, *EAS Publ. Ser.*, **99**

Claret, A., & Giménez, A. 1993, *A&A*, **277**, 487
 Duchêne, G., & Kraus, A. 2013, *ARA&A*, **51**, 269
 Gimenez, A., & Garcia-Pelayo, J. M. 1983, *Ap&SS*, **92**, 203
 Giménez, A., & Bastero, M. 1995, *Ap&SS*, **226**, 99
 Graczyk, D., Soszyński, I., Poleski, R., et al. 2011, *Acta Astron.*, **61**, 103
 Hilditch, R. W., Howarth, I. D., & Harries, T. J. 2005, *MNRAS*, **357**, 304
 Hong, K., Kim, S.-L., Lee, J. W., et al. 2015, *AJ*, **150**, 1
 Hong, K., Lee, J. W., Kim, S.-L., Koo, J.-R., & Lee, C.-U. 2016, *MNRAS*, **460**, 650
 Hong, K., Lee, J. W., Kim, S.-L., et al. 2019, *AJ*, **158**, 185
 Johnson, H. L. 1958, *Lowell Obs. Bull.*, **4**, 37
 Kim, C.-H., Kreiner, J. M., Zakrzewski, B., et al. 2018, *ApJS*, **235**, 41
 Kiminki, D. C., & Kobulnicky, H. A. 2012, *ApJ*, **751**, 4
 Massey, P. 2002, *ApJS*, **141**, 81
 Mayer, P. 1990, *Bull. Astron. Inst. Czech.*, **41**, 231
 Meibom, S., & Mathieu, R. D. 2005, *ApJ*, **620**, 970
 Pawlak, M., Soszyński, I., Udalski, A., et al. 2016, *Acta Astron.*, **66**, 421
 Peca, M. J., & Mamajek, E. E. 2013, *ApJS*, **208**, 9
 Prša, A., & Zwitter, T. 2005, *ApJ*, **628**, 426
 Rappaport, S., Deck, K., Levine, A., et al. 2013, *ApJ*, **768**, 33
 Southworth, J. 2012, *Orbital Couples: Pas de Deux in the Solar System and the Milky Way*, 51
 Tassoul, J.-L. 1988, *ApJ*, **324**, L71
 Torres, G., Andersen, J., & Giménez, A. 2010, *A&ARv*, **18**, 67
 Udalski, A., Szymanski, M., Kaluzny, J., Kubiak, M., & Mateo, M. 1992, *Acta Astron.*, **42**, 253
 Vilarde, F., Ribas, I., Jordi, C., Fitzpatrick, E. L., & Guinan, E. F. 2010, *A&A*, **509**, A70
 Wilson, R. E., & Devinney, E. J. 1971, *ApJ*, **166**, 605
 Wolf, M., Zasche, P., Kučáková, H., et al. 2017, *Acta Astron.*, **67**, 257
 Zahn, J.-P. 2008, *EAS Publ. Ser.*, **29**, 67
 Zaritsky, D., Harris, J., Thompson, I. B., Grebel, E. K., & Massey, P. 2002, *AJ*, **123**, 855
 Zasche, P., & Wolf, M. 2011, *A&A*, **527**, A43
 Zasche, P., & Wolf, M. 2013, *A&A*, **558**, A51
 Zasche, P., & Wolf, M. 2019, *AJ*, **157**, 87
 Zasche, P., Wolf, M., Vraštil, J., et al. 2014, *A&A*, **572**, A71
 Zasche, P., Wolf, M., Vraštil, J., & Pilarčík, L. 2015, *AJ*, **150**, 183
 Zejda, M., Skýba, O., Krajčovič, M., Gajdoš, P., & Fedurco, M. 2019, *Contrib. Astron. Obs. Skal. Pleso*, **49**, 132

Appendix A: Additional tables and figures

Table A.1. Relevant information for the analysed systems.

System name			RA	Dec	$V_{\max}^A$	$(B - V)^B$	$(B - V)_0^B$	$(B - V)^C$	$(B - V)_0^C$
OGLE III	OGLE II	MACHO			[mag]	[mag]	[mag]	[mag]	[mag]
OGLE LMC-ECL-00127			04:37:08.25	-69:06:55.1	17.60	—	—	-0.021	-0.097
OGLE LMC-ECL-00442			04:43:14.95	-70:33:58.6	15.45	—	—	-0.116	-0.295
OGLE LMC-ECL-00483			04:43:38.64	-69:43:34.6	18.58	—	—	0.153	-0.153
OGLE LMC-ECL-00510			04:43:51.87	-68:49:32.0	17.56	—	—	-0.458	0.139
OGLE LMC-ECL-00527			04:44:02.05	-67:20:33.2	18.07	—	—	-0.308	0.151
OGLE LMC-ECL-00648			04:45:18.51	-69:43:02.7	17.75	—	—	0.001	-0.160
OGLE LMC-ECL-00652			04:45:23.73	-69:09:55.7	16.61	-0.05	-0.217	-0.070	-0.181
OGLE LMC-ECL-00666			04:45:35.21	-68:29:14.3	17.38	—	—	0.061	-0.299
OGLE LMC-ECL-00737			04:46:17.60	-67:53:06.5	17.05	—	—	-0.052	-0.220
OGLE LMC-ECL-00868		44.1138.118	04:47:23.92	-69:38:28.9	17.92	0.19	-0.073	0.007	-0.139
OGLE LMC-ECL-00872		45.1157.218	04:47:25.72	-68:25:12.4	18.54	—	—	0.135	-0.189
OGLE LMC-ECL-00929			04:47:52.41	-66:52:28.8	18.47	—	—	-0.033	0.151
OGLE LMC-ECL-00955			04:48:01.92	-70:22:44.3	18.61	—	—	0.126	-0.131
OGLE LMC-ECL-01445		44.1626.46	04:50:35.32	-69:25:20.2	16.82	0.13	-0.108	-0.014	-0.229
OGLE LMC-ECL-02912*			04:55:14.81	-68:56:18.5	17.82	-0.26	0.034	0.267	-0.154
OGLE LMC-ECL-02943		18.2360.151	04:55:20.88	-68:51:10.1	17.62	—	—	0.031	-0.066
OGLE LMC-ECL-04957		24.3223.52	05:00:32.62	-67:48:17.1	18.08	—	—	0.251	-0.026
OGLE LMC-ECL-05345	SC15 152403	18.3449.3635	05:01:40.18	-68:51:05.5	15.38	-0.06	-0.271	-0.040	-0.274
OGLE LMC-ECL-06837	SC13 66307	19.4063.100	05:05:07.12	-68:16:22.9	17.17	—	—	0.056	-0.231
OGLE LMC-ECL-07578	SC13 183860	19.4300.349	05:06:43.25	-68:36:11.4	15.76	—	—	-0.072	-0.220
OGLE LMC-ECL-07585*		25.4321.184	05:06:44.73	-67:12:41.8	18.40	—	—	0.502	-0.340
OGLE LMC-ECL-07641	SC13 194100	19.4302.319	05:06:51.94	-68:25:46.5	14.22	—	—	-0.184	-0.195
OGLE LMC-ECL-07838		52.4447.1225	05:07:17.83	-66:50:37.6	16.81	—	—	0.030	-0.174
OGLE LMC-ECL-08311	SC11 103746	1.4530.37	05:08:27.80	-69:25:28.7	15.82	0.15	-0.346	-0.111	-0.238
OGLE LMC-ECL-08397*	SC11 162262		05:08:38.89	-68:45:45.7	14.69	—	—	0.085	-0.531
OGLE LMC-ECL-08439		19.4663.3317	05:08:44.93	-68:34:26.3	16.97	—	—	0.045	-0.170
OGLE LMC-ECL-08752	SC11 331573	79.4779.34	05:09:29.21	-68:55:02.6	14.92	-0.07	-0.302	-0.238	-0.117
OGLE LMC-ECL-08859		20.4795.146	05:09:45.57	-67:51:02.8	17.74	—	—	-0.019	-0.019
OGLE LMC-ECL-09186	SC10 16968	5.4894.3904	05:10:28.64	-69:20:47.9	15.73	0.18	-0.257	-0.012	-0.229
OGLE LMC-ECL-10302			05:13:25.33	-69:34:13.9	16.18	0.19	-0.259	—	—
OGLE LMC-ECL-10377	SC9 121731	5.5377.4656	05:13:36.22	-69:22:41.4	16.25	0.32	-0.382	-0.004	-0.216
OGLE LMC-ECL-10446			05:13:45.17	-67:19:47.8	16.07	—	—	-0.269	-0.001
OGLE LMC-ECL-10601		16.5523.48	05:14:08.60	-67:41:58.7	16.84	—	—	0.000	-0.179
OGLE LMC-ECL-10672			05:14:18.68	-66:37:26.7	18.03	—	—	0.019	-0.218
OGLE LMC-ECL-10867			05:14:49.59	-67:20:32.8	17.06	—	—	-0.029	-0.197
OGLE LMC-ECL-11183*			05:15:33.20	-70:20:21.0	17.33	—	—	0.840	-0.389
OGLE LMC-ECL-11320			05:15:51.42	-67:42:41.2	17.07	—	—	-0.036	-0.138
OGLE LMC-ECL-11351	SC8 168297	79.5746.319	05:15:57.02	-68:58:04.6	17.58	—	—	0.178	-0.180
OGLE LMC-ECL-11374		79.5750.262	05:16:01.13	-68:45:31.9	18.35	—	—	0.090	-0.104
OGLE LMC-ECL-11680	SC8 199230		05:16:50.17	-69:35:37.9	17.07	0.05	0.005	—	—
OGLE LMC-ECL-11854	SC8 312491	78.5981.322	05:17:15.40	-69:26:14.8	17.09	-0.28	-0.189	-0.082	-0.096
OGLE LMC-ECL-11929*	SC8 305721	78.5981.107	05:17:29.97	-69:27:58.5	15.83	-0.27	-0.168	-0.033	-0.097
OGLE LMC-ECL-12002			05:17:40.76	-67:59:47.1	16.76	—	—	0.031	-0.218
OGLE LMC-ECL-12043			05:17:45.49	-67:53:06.5	18.29	—	—	0.132	-0.142
OGLE LMC-ECL-12234*	SC7 150213	78.6100.606	05:18:12.60	-69:35:24.4	17.45	—	—	—	—
OGLE LMC-ECL-12323			05:18:25.01	-70:24:08.9	18.03	—	—	0.274	-0.226
OGLE LMC-ECL-12504*	SC7 278663		05:18:48.41	-69:33:57.5	17.52	—	—	—	—
OGLE LMC-ECL-12513*	SC7 278743	78.6222.903	05:18:50.01	-69:33:30.3	17.74	0.38	-0.418	—	—
OGLE LMC-ECL-12687	SC7 287027		05:19:15.46	-69:30:58.2	17.25	—	—	0.045	-0.042
OGLE LMC-ECL-12792	SC7 417231	78.6344.776	05:19:31.41	-69:26:59.9	18.33	—	—	-0.136	0.124
OGLE LMC-ECL-13039*	SC7 397930	78.6464.1043	05:20:07.88	-69:32:41.4	17.93	—	—	0.473	-0.387
OGLE LMC-ECL-13198*	SC6 58359	78.6463.505	05:20:35.07	-69:34:37.8	17.30	—	—	—	—
OGLE LMC-ECL-13202		3.6484.101	05:20:35.79	-68:12:17.2	17.39	-0.14	-0.030	0.064	-0.215
OGLE LMC-ECL-13321	SC6 143503		05:20:52.65	-69:52:24.3	18.04	—	—	0.407	-0.200
OGLE LMC-ECL-13407		3.6603.171	05:21:05.82	-68:20:10.4	17.62	0.560	-0.090	-0.011	-0.013
OGLE LMC-ECL-13452		16.6609.43	05:21:11.63	-67:55:34.6	16.53	—	—	-0.074	-0.243
OGLE LMC-ECL-13467		80.6591.25	05:21:14.51	-69:05:40.6	15.72	-0.11	-0.239	0.105	-0.277
OGLE LMC-ECL-13567		80.6712.1405	05:21:30.12	-69:07:15.8	18.04	-0.12	0.115	0.053	0.007
OGLE LMC-ECL-13601*	SC6 322535	78.6708.180	05:21:34.84	-69:25:34.6	16.70	—	—	0.266	-0.371
OGLE LMC-ECL-13809*			05:22:02.86	-67:58:46.6	16.93	—	—	0.154	-0.370
OGLE LMC-ECL-13842			05:22:07.88	-67:48:56.2	16.22	—	—	-0.090	-0.275
OGLE LMC-ECL-13851		3.6841.1394	05:22:08.65	-68:37:15.4	16.97	0.15	-0.176	-0.183	-0.104
OGLE LMC-ECL-13902			05:22:14.88	-67:47:16.7	17.64	—	—	-0.096	-0.182
OGLE LMC-ECL-14013			05:22:28.93	-68:04:54.9	17.19	—	—	0.090	-0.283
OGLE LMC-ECL-14159		80.6835.204	05:22:46.12	-69:00:50.6	17.45	0.43	-0.170	-0.087	-0.098
OGLE LMC-ECL-14462	SC5 124709	6.6940.6208	05:23:27.72	-70:02:53.3	15.97	—	—	-0.137	-0.215
OGLE LMC-ECL-15161	SC5 349685	77.7303.152	05:25:09.33	-70:04:22.6	16.41	—	—	0.072	-0.119
OGLE LMC-ECL-15288		80.7316.43	05:25:29.32	-69:10:56.0	15.97	-0.10	-0.218	-0.067	-0.189
OGLE LMC-ECL-15386		80.7318.1393	05:25:45.38	-69:01:54.8	17.67	—	—	-0.091	-0.059
OGLE LMC-ECL-15441	SC4 220655		05:25:53.52	-69:30:49.5	17.62	—	—	0.116	-0.133
OGLE LMC-ECL-15473		3.7443.37	05:25:57.49	-68:46:36.1	17.10	0.08	-0.099	0.155	-0.247
OGLE LMC-ECL-15496	SC4 177590		05:26:00.17	-69:51:15.4	18.11	—	—	-0.200	0.049
OGLE LMC-ECL-15664		80.7443.1746	05:26:21.14	-68:46:44.5	15.91	0.07	-0.273	0.024	-0.313
OGLE LMC-ECL-15764	SC4 281015	77.7547.1048	05:26:35.74	-69:55:54.6	18.03	—	—	0.030	-0.059
OGLE LMC-ECL-15779	SC4 296152	77.7548.325	05:26:36.54	-69:51:25.4	16.74	—	—	-0.395	0.099
OGLE LMC-ECL-16178			05:27:23.88	-69:05:00.7	16.53	0.09	-0.268	-0.085	-0.151
OGLE LMC-ECL-16310			05:27:41.15	-69:16:20.3	15.57	-0.03	-0.298	-0.068	-0.122

Notes. The full name from the OGLE II survey should be OGLE LMC-Scn nnnnnn. [A] Out-of-eclipse V magnitude based on OGLE database, see Graczyk et al. (2011) and Pawlak et al. (2016); [B] Photometric index by Massey (2002); [C] Photometric index by Zaritsky et al. (2002). An asterisk in the name of particular system flags that this system has dubious temperature T_1 as derived from its photometric index $(B - V)_0$. Therefore, for these stars their effective temperatures were only roughly estimated, see the text for details.

Table A.1. continued.

System name			RA	Dec	$V_{\max}^A$	$(B - V)^B$	$(B - V)_0^B$	$(B - V)^C$	$(B - V)_0^C$
OGLE III	OGLE II	MACHO			[mag]	[mag]	[mag]	[mag]	[mag]
OGLE LMC-ECL-16320*		7.7658.56	05:27:42.23	-70:35:59.6	15.93	—	—	-0.086	-0.348
OGLE LMC-ECL-16414			05:27:53.17	-69:03:51.6	16.53	0.16	-0.189	-0.216	-0.073
OGLE LMC-ECL-16442	SC3 46420	77.7669.3224	05:27:56.24	-69:53:12.3	19.03	—	—	0.127	-0.155
OGLE LMC-ECL-16625			05:28:18.80	-69:03:55.0	16.41	-0.15	-0.249	0.096	-0.178
OGLE LMC-ECL-16732			05:28:31.27	-69:13:40.7	16.10	0.13	-0.234	0.120	-0.260
OGLE LMC-ECL-16925			05:28:52.91	-70:20:52.6	17.05	—	—	0.036	-0.256
OGLE LMC-ECL-16928	SC3 317490		05:28:53.03	-69:32:27.2	18.09	—	—	0.062	-0.056
OGLE LMC-ECL-16983	SC3 329044	77.7917.602	05:29:00.17	-69:25:53.1	18.17	—	—	-0.005	-0.128
OGLE LMC-ECL-17030	SC3 317678	77.7916.397	05:29:06.00	-69:31:16.4	17.59	—	—	0.040	-0.137
OGLE LMC-ECL-17042		82.7926.48	05:29:07.25	-68:53:02.3	16.47	-0.03	-0.212	-0.192	-0.005
OGLE LMC-ECL-17183		7.7903.453	05:29:23.15	-70:22:28.0	17.80	—	—	-0.004	-0.055
OGLE LMC-ECL-17198			05:29:24.63	-68:42:13.1	14.12	-0.17	-0.268	-0.048	-0.241
OGLE LMC-ECL-17223			05:29:28.97	-68:44:10.8	16.54	-0.26	-0.184	-0.114	-0.213
OGLE LMC-ECL-17226*			05:29:29.33	-71:01:18.7	18.80	—	—	0.612	-0.522
OGLE LMC-ECL-17236			05:29:30.94	-68:40:12.8	17.75	—	—	-0.194	-0.042
OGLE LMC-ECL-17267		82.8049.37	05:29:34.38	-68:42:33.3	15.89	-0.13	-0.257	-0.124	-0.283
OGLE LMC-ECL-17283		21.8008.68	05:29:37.25	-71:26:43.4	17.34	—	—	-0.011	-0.151
OGLE LMC-ECL-17299	SC3 402931	77.8034.941	05:29:39.38	-69:44:46.3	18.11	—	—	0.006	-0.039
OGLE LMC-ECL-17406			05:29:51.43	-68:39:53.3	16.07	-0.17	-0.218	-0.084	-0.260
OGLE LMC-ECL-17498		7.8025.972	05:30:01.77	-70:21:22.1	17.91	—	—	-0.059	-0.167
OGLE LMC-ECL-17543		82.8047.152	05:30:07.32	-68:50:34.4	17.22	0.16	-0.115	-0.027	-0.149
OGLE LMC-ECL-17579			05:30:12.26	-68:30:32.6	15.78	0.03	-0.246	0.013	-0.235
OGLE LMC-ECL-17711	SC2 103719	77.8158.89	05:30:28.68	-69:30:03.7	16.57	-0.17	-0.212	-0.027	-0.262
OGLE LMC-ECL-17718		7.8140.136	05:30:29.24	-70:43:32.1	17.11	—	—	-0.084	-0.083
OGLE LMC-ECL-17774			05:30:35.11	-69:03:33.3	14.91	-0.06	-0.271	-0.100	-0.234
OGLE LMC-ECL-17777		82.8170.32	05:30:35.46	-68:42:45.5	16.36	0.01	-0.215	-0.026	-0.234
OGLE LMC-ECL-17800	SC2 214143	82.8160.2708	05:30:39.35	-69:23:57.1	16.97	—	—	-0.037	-0.186
OGLE LMC-ECL-17809		21.8126.151	05:30:40.46	-71:40:32.0	17.72	—	—	-0.032	-0.048
OGLE LMC-ECL-17923		4.8177.63	05:30:54.30	-68:16:17.4	17.48	0.16	-0.155	1.371	-0.494
OGLE LMC-ECL-18077			05:31:11.71	-71:04:21.2	18.02	—	—	0.060	-0.085
OGLE LMC-ECL-18152			05:31:21.80	-69:11:15.6	16.15	0.16	-0.275	0.229	-0.306
OGLE LMC-ECL-18174	SC2 315183	77.8281.58	05:31:24.61	-69:25:28.1	16.96	-0.13	-0.075	0.051	-0.165
OGLE LMC-ECL-18316*			05:31:43.49	-68:28:10.5	17.20	—	—	0.408	-0.419
OGLE LMC-ECL-18355*			05:31:47.85	-68:33:26.7	16.24	—	—	-0.938	0.318
OGLE LMC-ECL-18371		8.8424.131	05:31:49.93	-67:53:52.1	18.05	—	—	-0.002	-0.133
OGLE LMC-ECL-18408			05:31:54.55	-68:59:19.7	17.38	0.42	-0.061	0.578	-0.383
OGLE LMC-ECL-18500	SC2 351438		05:32:06.62	-70:04:56.5	17.97	—	—	0.235	-0.137
OGLE LMC-ECL-18501*		82.8407.1180	05:32:06.68	-69:04:34.5	18.00	—	—	0.374	-0.337
OGLE LMC-ECL-18579		82.8404.209	05:32:16.49	-69:15:35.7	17.03	0.17	-0.138	0.010	-0.216
OGLE LMC-ECL-19095			05:33:26.76	-69:10:51.3	16.63	-0.03	-0.248	-0.069	-0.137
OGLE LMC-ECL-19294		82.8648.78	05:33:53.71	-69:09:02.8	16.89	0.54	-0.189	-0.023	-0.201
OGLE LMC-ECL-19577	SC1 335438	81.8760.105	05:34:32.08	-69:45:36.2	16.08	—	—	-0.081	-0.218
OGLE LMC-ECL-19583		14.8744.3528	05:34:33.06	-70:49:10.4	17.78	—	—	0.046	-0.240
OGLE LMC-ECL-19624		8.8780.16	05:34:39.71	-68:21:55.5	15.94	-0.19	-0.280	-0.433	-0.153
OGLE LMC-ECL-19675			05:34:48.91	-68:19:46.7	17.13	-0.26	-0.105	-0.124	-0.177
OGLE LMC-ECL-19727*			05:34:57.01	-69:15:41.6	18.11	—	—	0.434	-0.455
OGLE LMC-ECL-19879	SC16 70662	81.8881.47	05:35:17.59	-69:43:18.8	15.02	—	—	0.014	-0.296
OGLE LMC-ECL-20053			05:35:41.09	-68:58:57.9	16.10	0.07	-0.213	0.117	-0.237
OGLE LMC-ECL-20066			05:35:42.99	-69:14:10.4	17.24	—	—	0.004	-0.176
OGLE LMC-ECL-20285			05:36:09.54	-68:55:27.4	16.29	—	—	-0.480	-0.012
OGLE LMC-ECL-20299		81.9005.17	05:36:10.74	-69:32:02.2	14.63	-0.08	-0.306	-0.019	-0.299
OGLE LMC-ECL-20384		82.9132.83	05:36:20.35	-69:06:15.7	16.57	0.10	-0.283	-0.061	-0.178
OGLE LMC-ECL-20550		82.9132.145	05:36:43.34	-69:06:07.1	17.03	-0.34	-0.116	-0.352	-0.090
OGLE LMC-ECL-20589		82.9130.25	05:36:48.74	-69:16:59.4	15.19	-0.13	-0.271	-0.109	-0.292
OGLE LMC-ECL-20648		81.9127.131	05:36:56.90	-69:28:50.3	16.65	0.09	-0.185	-0.010	-0.235
OGLE LMC-ECL-20735	SC16 240980	81.9238.590	05:37:07.73	-70:09:38.3	17.88	—	—	0.092	0.021
OGLE LMC-ECL-20783*	SC16 226238	11.9235.33	05:37:14.02	-70:20:01.5	15.67	—	—	0.329	-0.409
OGLE LMC-ECL-20860		81.9246.29	05:37:24.44	-69:34:19.6	15.87	—	—	-0.222	-0.173
OGLE LMC-ECL-21259			05:38:20.42	-69:03:10.4	15.98	0.69	-0.430	0.296	-0.267
OGLE LMC-ECL-21278			05:38:22.59	-69:21:04.5	17.38	—	—	0.361	-0.272
OGLE LMC-ECL-21479			05:38:46.72	-69:02:40.5	16.84	—	—	-0.451	-0.038
OGLE LMC-ECL-21647		50.9634.17	05:39:12.03	-67:55:54.1	16.54	-0.08	-0.173	-0.014	-0.200
OGLE LMC-ECL-21695			05:39:22.14	-68:31:58.2	16.85	-0.09	-0.181	-0.304	-0.142
OGLE LMC-ECL-21961*			05:40:02.01	-69:22:10.6	17.48	—	—	0.548	-0.445
OGLE LMC-ECL-21968			05:40:03.22	-69:19:54.7	15.90	—	—	0.041	-0.244
OGLE LMC-ECL-22069			05:40:17.90	-69:31:31.8	17.65	—	—	0.393	-0.308
OGLE LMC-ECL-22211*		76.9730.1611	05:40:38.42	-69:36:22.6	17.37	—	—	0.224	-0.345
OGLE LMC-ECL-22232	SC18 107244	76.9845.63	05:40:41.43	-69:59:01.4	16.39	—	—	-0.040	-0.212
OGLE LMC-ECL-22422*			05:41:10.20	-69:19:30.3	17.97	—	—	0.284	-0.316
OGLE LMC-ECL-22455	SC18 66331	11.9835.112	05:41:13.80	-70:39:49.5	17.18	—	—	0.105	-0.210
OGLE LMC-ECL-22494		76.9849.541	05:41:19.17	-69:41:43.3	18.59	—	—	0.088	-0.129
OGLE LMC-ECL-22613*		15.9946.7	05:41:37.74	-71:19:02.8	14.77	—	—	0.304	-0.529
OGLE LMC-ECL-22695*		76.9970.41	05:41:50.30	-69:42:24.5	16.13	—	—	-1.182	0.522
OGLE LMC-ECL-23298			05:43:26.23	-69:16:25.5	15.47	0.01	-0.275	0.118	-0.279
OGLE LMC-ECL-23323			05:43:32.02	-69:13:40.6	17.49	—	—	-0.007	-0.155
OGLE LMC-ECL-23920			05:45:54.86	-69:13:44.1	17.53	—	—	0.070	-0.189
OGLE LMC-ECL-24112		76.10813.52	05:46:44.34	-70:00:37.8	16.69	—	—	0.085	-0.153
OGLE LMC-ECL-24236*			05:47:18.17	-69:39:18.5	17.55	—	—	0.168	-0.333
OGLE LMC-ECL-24534			05:48:43.17	-70:01:00.3	16.24	—	—	-0.033	-0.292
OGLE LMC-ECL-24817			05:50:12.61	-69:55:26.4	18.10	—	—	-0.287	-0.085
OGLE LMC-ECL-25047			05:51:51.36	-70:01:21.1	18.05	—	—	-0.072	-0.213
OGLE LMC-ECL-25227		30.11783.137	05:53:17.33	-69:53:13.2	18.02	—	—	-0.067	-0.183
OGLE LMC-ECL-25743*			06:04:25.47	-68:55:28.1	15.29	—	—	0.105	-0.417
OGLE LMC-ECL-25885			06:07:52.60	-71:46:42.9	17.88	—	—	0.059	-0.023
OGLE LMC-ECL-25980*			06:10:48.42	-69:52:17.5	17.09	—	—	—	—

Table A.2. Parameters of the light curve fits and the apsidal motion.

System	i [deg]	T_1 [K]	T_2 [K]	L_1 [%]	L_2 [%]	L_3 [%]	R_1/a	R_2/a	HJD ₀ [2450000+]	P [d]	e	ω [deg]	U [yr]
OGLE LMC-ECL-00127	80.31 (0.54)	12500 (fixed)	12153 (189)	57.6 (1.9)	42.3 (1.7)	0	0.252 (5)	0.230 (3)	3400.7935 (24)	1.9716646 (19)	0.020 (8)	118.3 (1.2)	47.8 (4.9)
OGLE LMC-ECL-00442	87.02 (1.12)	29000 (fixed)	18691 (302)	78.7 (2.3)	11.3 (1.2)	10.0 (0.7)	0.194 (3)	0.108 (4)	5552.2497 (115)	3.4108511 (123)	0.341 (17)	49.7 (7.8)	94.1 (10.3)
OGLE LMC-ECL-00483	86.94 (0.96)	15700 (fixed)	9767 (619)	70.4 (7.0)	12.3 (2.3)	17.3 (5.2)	0.197 (11)	0.118 (9)	5551.8390 (89)	1.9408981 (57)	0.139 (26)	186.9 (15.3)	77.0 (24.7)
OGLE LMC-ECL-00510	83.71 (0.67)	8270 (fixed)	8179 (118)	50.7 (2.1)	46.3 (0.8)	2.9 (1.3)	0.228 (3)	0.217 (2)	5552.2803 (92)	2.4828516 (130)	0.096 (12)	171.9 (6.7)	106.7 (18.9)
OGLE LMC-ECL-00527	80.68 (0.35)	8150 (fixed)	7388 (103)	63.2 (1.5)	36.7 (1.4)	0	0.227 (2)	0.194 (2)	5552.5222 (21)	1.7258405 (14)	0.045 (16)	106.0 (2.3)	57.9 (11.5)
OGLE LMC-ECL-00648	84.13 (0.64)	16200 (fixed)	14675 (257)	77.3 (2.6)	20.1 (1.3)	2.7 (2.0)	0.276 (3)	0.151 (4)	5553.3481 (33)	1.5805259 (29)	0.046 (11)	106.1 (2.0)	26.8 (9.0)
OGLE LMC-ECL-00652	86.34 (0.29)	20600 (fixed)	21103 (222)	25.1 (1.2)	74.9 (2.0)	0	0.139 (2)	0.232 (3)	5553.0384 (102)	3.2610612 (213)	0.202 (21)	68.1 (9.4)	92.1 (12.6)
OGLE LMC-ECL-00666	88.21 (0.56)	30000 (fixed)	21888 (511)	45.4 (3.2)	12.7 (1.3)	41.9 (2.8)	0.247 (5)	0.163 (4)	5552.9386 (24)	1.6029021 (20)	0.036 (10)	162.6 (1.8)	39.9 (5.2)
OGLE LMC-ECL-00737	89.27 (0.24)	20600 (fixed)	20615 (210)	49.0 (0.4)	51.0 (0.5)	0	0.209 (3)	0.211 (3)	5601.1048 (45)	1.9848417 (86)	0.111 (32)	310.5 (3.4)	44.1 (8.9)
OGLE LMC-ECL-00868	85.18 (0.71)	10700 (fixed)	11476 (234)	35.3 (1.8)	59.6 (2.1)	5.1 (1.2)	0.148 (2)	0.183 (3)	5600.2204 (123)	2.2747035 (224)	0.203 (36)	167.1 (12.9)	114.8 (18.2)
OGLE LMC-ECL-00872	88.29 (0.85)	17800 (fixed)	14181 (427)	67.2 (0.3)	32.8 (0.3)	0	0.227 (3)	0.186 (4)	5600.0326 (37)	1.2823707 (23)	0.071 (17)	127.6 (2.5)	32.8 (8.1)
OGLE LMC-ECL-00929	89.53 (0.59)	8170 (fixed)	7890 (208)	56.0 (2.5)	44.0 (2.2)	0	0.177 (5)	0.163 (9)	5600.4775 (78)	1.8515324 (103)	0.210 (45)	262.5 (12.0)	103.9 (19.3)
OGLE LMC-ECL-00955	85.37 (0.37)	14000 (fixed)	17175 (536)	35.6 (1.7)	60.3 (0.7)	4.1 (2.9)	0.144 (5)	0.162 (6)	5599.7752 (146)	2.8025063 (221)	0.209 (59)	126.6 (11.9)	195.1 (33.0)
OGLE LMC-ECL-01445	86.61 (0.22)	12500 (fixed)	12380 (155)	57.8 (1.2)	32.6 (0.5)	9.6 (6.1)	0.236 (2)	0.179 (2)	6001.9480 (89)	2.2912938 (68)	0.129 (20)	164.4 (7.1)	54.5 (5.8)
OGLE LMC-ECL-02912	78.18 (0.52)	14000 (fixed)	13031 (213)	58.4 (2.0)	39.0 (1.8)	2.6 (1.8)	0.224 (4)	0.195 (3)	6001.7281 (14)	2.1106452 (17)	0.020 (11)	264.0 (17.2)	71.9 (18.3)
OGLE LMC-ECL-02943	81.87 (0.47)	10700 (fixed)	10044 (135)	60.2 (1.3)	38.8 (1.7)	0.9 (0.8)	0.203 (7)	0.167 (5)	6002.3439 (33)	3.2126214 (30)	0.090 (23)	100.1 (1.8)	112.8 (13.2)
OGLE LMC-ECL-04957	82.33 (0.43)	10000 (fixed)	9383 (115)	60.8 (1.4)	39.2 (1.0)	0	0.224 (2)	0.189 (2)	5003.0905 (23)	1.4541166 (11)	0.065 (8)	87.0 (2.4)	37.4 (3.9)
OGLE LMC-ECL-05345	83.85 (0.27)	26000 (fixed)	26050 (288)	56.0 (0.9)	43.4 (1.1)	0.6 (0.5)	0.182 (2)	0.162 (3)	5002.5639 (91)	4.0348631 (121)	0.261 (22)	137.2 (6.0)	131.4 (14.7)
OGLE LMC-ECL-06837	83.10 (0.39)	22500 (fixed)	21103 (319)	54.8 (1.5)	45.2 (1.2)	0	0.175 (4)	0.165 (3)	6002.6578 (52)	2.7470370 (42)	0.048 (7)	104.8 (1.3)	9.9 (0.6)
OGLE LMC-ECL-07578	88.03 (0.48)	20600 (fixed)	19882 (257)	52.2 (0.9)	28.7 (1.0)	19.1 (2.3)	0.211 (4)	0.186 (7)	5002.8096 (78)	4.0185993 (98)	0.141 (15)	316.8 (7.9)	146.0 (15.2)
OGLE LMC-ECL-07585	88.88 (0.54)	11000 (fixed)	9850 (210)	54.3 (1.6)	45.6 (1.4)	0	0.201 (5)	0.198 (4)	5000.7113 (34)	1.5331843 (40)	0.059 (22)	302.7 (18.8)	39.1 (22.3)
OGLE LMC-ECL-07641	82.32 (0.80)	18500 (fixed)	19364 (776)	33.7 (1.2)	50.2 (2.2)	16.1 (3.4)	0.154 (7)	0.181 (6)	5495.0273 (112)	6.3299708 (230)	0.265 (110)	89.8 (9.0)	198.9 (52.6)
OGLE LMC-ECL-07838	87.69 (1.09)	17000 (fixed)	16180 (328)	63.6 (3.0)	35.2 (1.6)	1.2 (1.2)	0.233 (4)	0.169 (5)	4002.2882 (61)	2.6211802 (81)	0.123 (43)	102.2 (2.7)	83.3 (10.9)
OGLE LMC-ECL-08311	75.76 (0.31)	23500 (fixed)	17805 (241)	64.4 (1.1)	35.6 (0.7)	0	0.219 (2)	0.202 (3)	4001.6423 (53)	2.3454109 (42)	0.107 (12)	84.7 (4.4)	35.4 (1.3)
OGLE LMC-ECL-08397	82.80 (0.62)	30000 (fixed)	26080 (136)	42.8 (5.2)	30.7 (3.1)	26.5 (4.6)	0.207 (7)	0.200 (4)	4003.0302 (107)	3.1317961 (170)	0.169 (21)	138.9 (7.1)	58.6 (3.4)
OGLE LMC-ECL-08439	86.11 (1.08)	16700 (fixed)	16657 (505)	42.7 (3.3)	37.7 (2.0)	19.6 (4.8)	0.247 (6)	0.233 (3)	4002.1008 (32)	2.0488466 (12)	0.040 (7)	71.0 (1.6)	39.5 (3.1)
OGLE LMC-ECL-08752	80.74 (0.35)	31500 (fixed)	24970 (213)	62.7 (0.9)	37.3 (0.7)	0	0.221 (3)	0.211 (3)	6157.0514 (44)	2.6788383 (65)	0.039 (9)	14.1 (2.2)	49.6 (5.0)
OGLE LMC-ECL-08859	77.79 (0.59)	10000 (fixed)	8721 (234)	51.8 (1.4)	38.1 (1.6)	10.1 (3.5)	0.245 (6)	0.233 (5)	4001.5476 (9)	1.0877549 (5)	0.046 (4)	249.4 (1.1)	15.7 (1.2)
OGLE LMC-ECL-09186	81.78 (0.12)	24500 (fixed)	28734 (108)	41.6 (0.8)	58.4 (0.9)	0	0.182 (3)	0.186 (4)	5002.6794 (69)	3.7734273 (141)	0.236 (16)	148.1 (5.9)	126.1 (34.9)
OGLE LMC-ECL-10302	75.99 (1.27)	24500 (fixed)	22720 (297)	25.0 (0.3)	19.8 (0.4)	55.2 (1.4)	0.234 (2)	0.220 (3)	4001.0612 (6)	1.5401250 (12)	0.008 (2)	35.2 (6.0)	17.9 (1.4)
OGLE LMC-ECL-10377	85.42 (0.46)	20600 (fixed)	17949 (132)	56.7 (2.7)	43.3 (2.5)	0	0.240 (9)	0.214 (8)	2246.1620 (8)	2.1087293 (11)	0.030 (4)	329.8 (4.3)	32.7 (2.1)
OGLE LMC-ECL-10446	80.17 (0.91)	10000 (fixed)	9025 (204)	59.3 (1.6)	36.4 (2.1)	4.3 (2.7)	0.230 (11)	0.193 (9)	5001.3796 (59)	2.1452228 (77)	0.096 (13)	146.9 (4.8)	36.4 (8.5)
OGLE LMC-ECL-11854	79.62 (0.28)	17000 (fixed)	14687 (190)	65.7 (0.6)	34.3 (0.5)	0	0.205 (3)	0.164 (3)	4002.0628 (179)	3.2837060 (242)	0.225 (63)	156.0 (11.7)	119.4 (28.9)
OGLE LMC-ECL-10672	88.34 (0.83)	20600 (fixed)	17942 (275)	65.7 (2.4)	32.6 (1.9)	1.7 (1.4)	0.240 (4)	0.187 (5)	4002.4626 (11)	1.7056091 (14)	0.031 (9)	293.3 (12.9)	52.8 (19.3)
OGLE LMC-ECL-10867	82.86 (0.25)	18500 (fixed)	17569 (174)	63.7 (2.1)	36.3 (1.7)	0	0.236 (5)	0.176 (7)	4002.4395 (19)	1.8582461 (25)	0.043 (11)	296.4 (7.2)	60.5 (11.0)
OGLE LMC-ECL-11183	87.77 (1.07)	16000 (fixed)	26957 (503)	5.7 (0.8)	48.4 (8.2)	45.9 (7.0)	0.155 (8)	0.298 (11)	4000.9668 (85)	2.5808061 (107)	0.199 (13)	88.5 (9.4)	48.1 (7.6)
OGLE LMC-ECL-11320	84.51 (0.30)	14500 (fixed)	14410 (162)	63.3 (1.5)	34.1 (1.3)	2.6 (2.1)	0.243 (2)	0.178 (2)	4002.9282 (30)	2.5380708 (62)	0.052 (16)	123.0 (11.8)	74.5 (15.2)
OGLE LMC-ECL-11351	77.87 (0.29)	17000 (fixed)	20072 (266)	52.0 (0.7)	48.0 (0.6)	0	0.212 (3)	0.181 (3)	4002.9247 (72)	2.4103248 (69)	0.150 (23)	64.7 (5.0)	92.5 (13.7)
OGLE LMC-ECL-11374	87.94 (0.32)	12500 (fixed)	12544 (137)	55.3 (1.4)	43.8 (1.7)	0.9 (0.8)	0.231 (4)	0.210 (5)	4003.4547 (25)	2.0154752 (26)	0.045 (12)	23.9 (3.1)	88.0 (22.8)
OGLE LMC-ECL-11680	81.45 (0.35)	10000 (fixed)	10386 (177)	48.6 (0.9)	51.4 (1.1)	0	0.183 (2)	0.185 (2)	4001.6785 (56)	2.1649015 (68)	0.131 (30)	61.1 (4.0)	72.0 (5.1)
OGLE LMC-ECL-11854	80.37 (0.19)	17000 (fixed)	16556 (252)	72.9 (2.6)	24.4 (0.9)	2.7 (1.7)	0.259 (3)	0.153 (3)	5001.3761 (18)	2.4000588 (35)	0.041 (12)	71.5 (2.9)	66.3 (4.3)
OGLE LMC-ECL-11929	75.30 (0.48)	23000 (fixed)	21808 (119)	66.1 (1.7)	33.1 (0.8)	0.8 (0.8)	0.281 (5)	0.210 (4)	5000.9802 (61)	4.4228109 (101)	0.050 (13)	355.5 (4.5)	87.8 (5.0)
OGLE LMC-ECL-12002	81.65 (0.17)	20600 (fixed)	18815 (185)	57.7 (0.7)	42.3 (0.8)	0	0.208 (4)	0.192 (5)	4000.5253 (40)	2.1911826 (129)	0.064 (19)	141.6 (3.8)	57.4 (9.2)
OGLE LMC-ECL-12043	81.71 (2.30)	14500 (fixed)	15377 (395)	31.5 (2.2)	41.2 (3.0)	27.3 (4.9)	0.199 (12)	0.205 (11)	4002.7978 (41)	1.3432745 (73)	0.150 (14)	146.1 (2.3)	48.7 (4.6)
OGLE LMC-ECL-12234	83.48 (0.38)	16000 (fixed)	15342 (240)	68.7 (0.6)	29.2 (0.7)	2.1 (1.4)	0.252 (2)	0.171 (2)	5003.9357 (68)	2.5755734 (91)	0.108 (15)	205.7 (3.0)	87.9 (2.1)
OGLE LMC-ECL-12323	86.39 (0.21)	20600 (fixed)	20872 (351)	51.3 (1.3)	45.8 (2.2)	2.9 (2.5)	0.146 (2)	0.142 (3)	4002.3660 (162)	2.9617909 (164)	0.139 (22)	61.9 (12.7)	183.7 (33.9)
OGLE LMC-ECL-12504	80.94 (0.33)	15000 (fixed)	18530 (313)	23.7 (3.1)	44.3 (3.7)	32.0 (5.0)	0.181 (4)	0.217 (5)	4002.5246 (59)	2.3873668 (117)	0.175 (41)	65.0 (4.8)	159.4 (48.0)
OGLE LMC-ECL-12513	82.04 (0.75)	14000 (fixed)	12527 (329)	31.3 (1.5)	17.0 (0.9)	51.7 (6.2)	0.212 (9)	0.164 (6)	3539.6785 (38)	1.6462861 (32)	0.110 (27)	109.1 (3.2)	44.1 (9.4)
OGLE LMC-ECL-12687	79.39 (0.37)	10000 (fixed)	9309 (188)	60.8 (2.0)	39.2 (1.8)	0	0.244 (5)	0.213 (3)	4003.0971 (11)	1.6872665 (10)	0.031 (4)	19.3 (4.6)	32.2 (2.7)
OGLE LMC-ECL-12792	83.98 (0.82)	8300 (fixed)	8179 (214)	50.7 (2.4)	48.4 (1.1)	0.9 (0.8)	0.246 (7)	0.238 (4)	4002.9299 (14)	1.7357179 (88)	0.047 (21)	253.9 (7.7)	194.2 (74.8)
OGLE LMC-ECL-13039	84.12 (0.34)	13500 (fixed)	13557 (156)	37.0 (0.5)	63.0 (0.5)	0	0.172 (2)	0.223 (2)	4003.1363 (29)	1.5053762 (31)	0.096 (5)	9.1 (12.4)	45.5 (3.1)
OGLE LMC-ECL-13198	78.55 (0.16)	16000 (fixed)	18256 (302)	44.2 (0.6)	54.9 (0.7)	0.9 (0.5)	0.201 (3)	0.203 (4)	4001.4109 (51)	2.1174661 (74)	0.114 (11)	36.1 (4.9)	63.0 (4.9)
OGLE LMC-ECL-13202	88.82 (0.32)	10400 (fixed)	11061 (135)	42.6 (0.8)	54.6 (1.1)	2.8 (0.7)	0.187 (2)	0.202 (2)	4002.3909 (67)	2.2752552 (111)	0.151 (32)	66.0 (2.8)	81.7 (11.0)
OGLE LMC-ECL-13321	82.30 (0.19)	18500 (fixed)	21923 (238)	41.8 (0.5)	58.7 (0.9)	0	0.185 (4)	0.198 (9)	4000.9603 (33)	1.6517623 (42)	0.160 (46)	114.8 (2.1)	63.0 (29.6)
OGLE LMC-ECL-13407	80.31 (0.35)	11500 (fixed)	11130 (185)	51.9 (0.7)	48.1 (0.5)	0	0.217 (4)	0.215 (3)	4001.9580 (26)	1.9333573 (25)	0.080 (6)	96.7 (2.7)	62.7 (5.2)
OGLE LMC-ECL-13452	85.36 (0.23)	24500 (fixed)	23186 (123)	53.6 (1.0)	46.3 (0.8)	0	0.207 (3)	0.201 (2)	4002.0813 (37)	1.9627478 (56)	0.086 (4)	333.4 (1.6)	39.2 (2.5)
OGLE LMC-ECL-13467	85.71 (0.39)	25200 (fixed)	23906 (174)	55.5 (1.6)	43.7 (0.9)	0.8 (0.6)	0.231 (3)	0.214 (3)	4002.3241 (34)	2.5059763 (61)	0.063 (10)	80.7 (3.0)	46.9 (3.7)
OGLE LMC-ECL-13567	87.52 (0.48)	8400 (fixed)	7875 (49)	59.4 (0.7)	40.2 (0.6)	0.5 (0.5)	0.259 (2)	0.227 (2)	4001.6849 (9)	1.1749927 (8)	0.021 (2)	83.2 (1.4)	14.1 (1.1)
OGLE LMC-ECL-13601	80.49 (0.14)	19000 (fixed)	19481 (166)	46.5 (0.6)	55.5 (0.6)	0	0.192 (2)	0.202 (3)	4003.4649 (25)	2.5988993 (33)	0.097 (22)	100.1 (2.8)	91.2 (12.3)
OGLE LMC-ECL-13809	88.90 (0.19)	18000 (fixed)	16362 (145)	47.6 (0.8)	44.0 (1.0)	8.2 (2.4)	0.214 (3)	0.213 (3)	4002.1345 (27)	1.7508997 (52)	0.073 (25)	68.7 (4.7)	34.9 (10.8)
OGLE LMC-ECL-13842	80.13 (0.25)	26000 (fixed)	19994 (117)	62.8 (2.3)	37.0 (1.4)	0.2 (0.2)	0.209 (4)	0.201 (4)	4002.1696 (66)	2.2447821 (204)	0.110 (33)	128.9 (5.9)	46.3 (13.0)
OGLE LMC-ECL-13851	81.61 (0.16)	17000 (fixed)	15948 (102)	53.8 (0.9)	46.2 (0.7)	0</							

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Table A.2. continued.

System	i [deg]	T_1 [K]	T_2 [K]	L_1 [%]	L_2 [%]	L_3 [%]	R_1/a	R_2/a	HJD ₀ [2450000+]	P [d]	e	ω [deg]	U [yr]
OGLE LMC-ECL-17042	80.98 (0.27)	20600 (fixed)	22193 (224)	46.6 (0.6)	53.4 (0.7)	0	0.180 (2)	0.182 (3)	4002.4456 (83)	2.6105475 (135)	0.200 (34)	127.8 (4.5)	80.3 (9.8)
OGLE LMC-ECL-17183	83.41 (0.43)	10400 (fixed)	11587 (163)	36.6 (1.0)	53.0 (1.2)	11.3 (1.2)	0.182 (7)	0.201 (8)	4001.7230 (57)	2.2069498 (85)	0.158 (16)	133.7 (8.0)	112.6 (7.9)
OGLE LMC-ECL-17198	82.48 (0.50)	24500 (fixed)	23583 (208)	29.1 (1.7)	28.1 (1.3)	42.8 (2.4)	0.226 (4)	0.222 (3)	5000.1246 (69)	3.2908144 (224)	0.079 (13)	155.3 (5.7)	74.7 (16.1)
OGLE LMC-ECL-17223	76.32 (0.38)	17500 (fixed)	16835 (531)	54.7 (1.9)	37.5 (1.6)	7.8 (3.0)	0.170 (5)	0.144 (5)	5000.6431 (138)	2.6021867 (379)	0.208 (75)	134.0 (14.3)	104.9 (36.7)
OGLE LMC-ECL-17226	86.04 (0.45)	9500 (fixed)	8802 (193)	59.3 (1.4)	40.7 (1.2)	0	0.253 (4)	0.237 (8)	6000.6648 (9)	0.9879314 (10)	0.037 (4)	319.9 (3.6)	11.1 (1.0)
OGLE LMC-ECL-17236	77.27 (0.43)	10400 (fixed)	9976 (309)	45.9 (1.1)	30.1 (1.7)	24.0 (3.5)	0.226 (3)	0.183 (3)	4002.6218 (42)	1.5755586 (104)	0.118 (19)	52.2 (4.1)	29.6 (3.4)
OGLE LMC-ECL-17267	70.88 (0.32)	25000 (fixed)	19240 (286)	43.8 (0.9)	27.3 (1.4)	28.9 (1.6)	0.238 (4)	0.236 (2)	5001.2120 (51)	1.8805590 (52)	0.032 (5)	25.1 (2.7)	28.1 (1.6)
OGLE LMC-ECL-17283	83.26 (0.23)	15700 (fixed)	12316 (152)	54.8 (1.6)	37.4 (0.8)	7.8 (2.3)	0.186 (3)	0.181 (3)	4003.4638 (93)	2.0727585 (160)	0.227 (43)	173.4 (5.0)	59.6 (4.8)
OGLE LMC-ECL-17299	83.11 (0.26)	10400 (fixed)	9947 (145)	58.4 (2.3)	41.6 (1.8)	0	0.194 (5)	0.174 (4)	4001.6258 (64)	1.7431951 (9)	0.203 (14)	72.7 (2.4)	74.5 (11.2)
OGLE LMC-ECL-17406	85.17 (0.91)	21000 (fixed)	12184 (270)	38.9 (1.7)	6.1 (0.5)	55.0 (3.2)	0.237 (3)	0.139 (2)	5002.9681 (11)	1.9407060 (34)	0.120 (72)	93.8 (13.2)	110.6 (24.1)
OGLE LMC-ECL-17498	86.01 (0.29)	16700 (fixed)	12948 (201)	57.2 (1.2)	39.5 (1.0)	3.3 (1.0)	0.180 (3)	0.174 (2)	4000.1153 (90)	2.5878412 (162)	0.251 (12)	256.0 (6.6)	132.7 (10.7)
OGLE LMC-ECL-17543	82.12 (0.17)	12500 (fixed)	11669 (102)	57.1 (0.9)	40.7 (2.0)	2.2 (1.4)	0.187 (4)	0.168 (2)	4000.0572 (52)	2.6029786 (90)	0.106 (20)	138.8 (3.8)	131.3 (32.0)
OGLE LMC-ECL-17579	77.23 (0.71)	24000 (fixed)	20518 (263)	32.5 (0.8)	23.4 (2.7)	44.1 (4.8)	0.236 (3)	0.233 (3)	4001.1745 (18)	1.5486575 (44)	0.041 (17)	267.4 (13.9)	72.1 (26.9)
OGLE LMC-ECL-17711	73.22 (0.10)	20600 (fixed)	20232 (179)	53.1 (0.4)	46.7 (0.4)	0.2 (0.2)	0.227 (2)	0.217 (2)	4000.9684 (15)	1.9613503 (21)	0.037 (7)	71.8 (1.5)	31.7 (2.3)
OGLE LMC-ECL-17718	87.23 (0.38)	10700 (fixed)	9978 (99)	53.0 (0.6)	47.0 (0.7)	0	0.203 (3)	0.202 (3)	5501.6279 (19)	2.0641028 (19)	0.039 (14)	142.5 (9.7)	66.7 (11.4)
OGLE LMC-ECL-17774	79.35 (0.23)	25500 (fixed)	23836 (333)	32.2 (1.7)	29.8 (1.3)	38.0 (3.5)	0.188 (4)	0.174 (3)	5798.4747 (47)	3.9294300 (173)	0.070 (13)	319.7 (3.4)	7.2 (0.2)
OGLE LMC-ECL-17777	86.17 (0.31)	20600 (fixed)	20376 (176)	52.4 (0.9)	47.0 (1.1)	0.6 (0.6)	0.199 (2)	0.195 (2)	4002.2267 (91)	2.8638071 (160)	0.125 (11)	35.8 (6.1)	87.3 (7.8)
OGLE LMC-ECL-17800	74.26 (0.14)	17700 (fixed)	11632 (188)	62.8 (1.3)	28.7 (0.9)	8.5 (1.3)	0.237 (4)	0.222 (3)	4001.9965 (12)	1.4354526 (12)	0.035 (12)	206.8 (5.0)	20.5 (1.7)
OGLE LMC-ECL-17809	87.98 (0.32)	10400 (fixed)	10551 (97)	47.9 (1.0)	52.1 (0.9)	0	0.210 (2)	0.213 (3)	4002.3658 (49)	2.2079038 (85)	0.111 (30)	65.0 (3.8)	70.2 (4.0)
OGLE LMC-ECL-17923	89.53 (0.49)	15700 (fixed)	15628 (129)	52.9 (0.5)	47.1 (0.4)	0	0.208 (2)	0.196 (2)	4002.8307 (77)	2.5538851 (145)	0.150 (27)	145.7 (5.5)	82.6 (14.1)
OGLE LMC-ECL-18077	82.54 (0.60)	10700 (fixed)	12604 (300)	39.4 (0.6)	52.9 (1.8)	7.7 (1.6)	0.159 (5)	0.165 (6)	5002.2916 (31)	1.7835501 (88)	0.221 (98)	88.5 (18.7)	112.9 (35.6)
OGLE LMC-ECL-18152	78.24 (0.29)	26000 (fixed)	22707 (328)	64.1 (0.9)	32.3 (1.2)	3.6 (2.0)	0.208 (4)	0.168 (4)	5001.9415 (47)	2.5629074 (168)	0.098 (22)	98.3 (7.7)	45.3 (8.2)
OGLE LMC-ECL-18174	79.75 (0.15)	10700 (fixed)	11510 (125)	44.3 (0.4)	55.7 (0.4)	0	0.207 (2)	0.219 (2)	4003.0395 (39)	2.5366697 (63)	0.129 (11)	123.2 (2.9)	81.7 (7.0)
OGLE LMC-ECL-18316	89.70 (0.47)	17000 (fixed)	16256 (190)	62.5 (1.3)	35.2 (1.1)	2.3 (1.4)	0.226 (3)	0.171 (3)	5001.7243 (80)	2.1080445 (202)	0.166 (30)	103.1 (5.1)	24.1 (3.8)
OGLE LMC-ECL-18355	79.65 (0.58)	21000 (fixed)	12642 (509)	44.0 (1.6)	7.6 (0.8)	48.4 (3.2)	0.233 (4)	0.139 (9)	5002.0211 (41)	2.1675189 (126)	0.141 (19)	250.0 (4.2)	45.1 (9.9)
OGLE LMC-ECL-18371	81.36 (0.25)	14000 (fixed)	14885 (197)	36.9 (0.6)	63.1 (0.6)	0	0.186 (3)	0.234 (4)	5001.9229 (24)	1.7069521 (25)	0.056 (11)	91.0 (3.6)	48.6 (18.7)
OGLE LMC-ECL-18408	81.27 (0.19)	10600 (fixed)	11018 (162)	47.8 (0.3)	52.2 (0.3)	0	0.157 (2)	0.159 (2)	4002.5205 (85)	2.3382018 (253)	0.151 (52)	137.1 (14.9)	142.2 (72.6)
OGLE LMC-ECL-18500	82.08 (0.25)	14500 (fixed)	14602 (208)	47.9 (0.3)	52.1 (0.4)	0	0.199 (3)	0.207 (4)	5002.2085 (63)	2.3546062 (110)	0.166 (46)	79.6 (21.0)	151.7 (77.8)
OGLE LMC-ECL-18501	85.26 (0.33)	13000 (fixed)	15439 (457)	40.0 (2.2)	53.5 (3.2)	6.5 (2.7)	0.148 (4)	0.151 (4)	5002.6321 (87)	2.3935782 (121)	0.290 (109)	97.0 (11.5)	149.2 (82.0)
OGLE LMC-ECL-18579	80.73 (0.44)	14500 (fixed)	12708 (346)	63.1 (2.4)	32.3 (4.0)	4.6 (1.1)	0.163 (3)	0.130 (7)	4002.1199 (160)	3.1174213 (199)	0.301 (43)	145.8 (7.3)	105.6 (16.1)
OGLE LMC-ECL-19095	81.90 (0.17)	24500 (fixed)	30371 (232)	39.7 (0.6)	58.5 (1.3)	1.8 (0.8)	0.169 (2)	0.170 (3)	4002.1948 (151)	2.9751066 (81)	0.249 (94)	126.5 (13.4)	103.7 (22.3)
OGLE LMC-ECL-19294	84.00 (0.30)	18500 (fixed)	8067 (169)	70.7 (1.2)	29.3 (1.0)	0	0.220 (3)	0.172 (3)	4003.8965 (82)	2.7363868 (138)	0.148 (27)	245.6 (6.1)	100.2 (7.5)
OGLE LMC-ECL-19577	73.06 (0.22)	20600 (fixed)	22170 (214)	35.7 (0.6)	64.3 (0.7)	0	0.220 (2)	0.277 (3)	3006.7611 (13)	1.6514537 (16)	0.051 (4)	204.5 (7.0)	12.8 (1.0)
OGLE LMC-ECL-19583	85.91 (0.42)	24500 (fixed)	20917 (351)	50.2 (2.0)	38.4 (1.6)	11.4 (2.5)	0.175 (3)	0.173 (3)	4002.6050 (118)	2.1894745 (130)	0.212 (18)	218.2 (5.2)	99.0 (8.2)
OGLE LMC-ECL-19624	81.27 (0.33)	26000 (fixed)	24418 (217)	59.3 (1.7)	40.7 (1.9)	0	0.193 (3)	0.164 (2)	3002.2117 (155)	2.7015912 (227)	0.279 (25)	40.9 (3.0)	50.9 (4.2)
OGLE LMC-ECL-19675	89.54 (0.59)	12500 (fixed)	12103 (260)	50.7 (1.2)	48.1 (0.8)	1.2 (1.1)	0.178 (4)	0.178 (4)	4003.1777 (53)	2.7038366 (203)	0.149 (61)	108.1 (4.7)	172.5 (19.4)
OGLE LMC-ECL-19727	84.50 (0.16)	12500 (fixed)	18828 (370)	26.2 (0.7)	73.7 (0.9)	0	0.129 (2)	0.160 (3)	3007.0991 (71)	2.6668363 (215)	0.350 (110)	77.9 (8.3)	158.8 (45.1)
OGLE LMC-ECL-19879	86.96 (0.48)	29000 (fixed)	28978 (305)	49.3 (0.9)	37.4 (1.5)	13.2 (3.0)	0.187 (2)	0.166 (6)	2282.2391 (127)	3.8818771 (278)	0.219 (19)	96.3 (6.6)	103.4 (16.7)
OGLE LMC-ECL-20053	75.59 (0.63)	20600 (fixed)	20207 (193)	47.9 (1.1)	41.2 (0.8)	10.9 (2.4)	0.234 (7)	0.219 (5)	4002.0741 (125)	1.9068881 (22)	0.038 (11)	80.2 (2.9)	25.0 (1.9)
OGLE LMC-ECL-20066	83.01 (0.26)	10700 (fixed)	12812 (166)	65.7 (0.6)	34.3 (0.4)	0	0.188 (5)	0.161 (5)	5004.1508 (81)	2.4753628 (198)	0.209 (38)	269.7 (4.3)	50.9 (18.8)
OGLE LMC-ECL-20285	84.78 (0.17)	10000 (fixed)	9496 (111)	51.3 (1.8)	48.7 (1.6)	0	0.249 (2)	0.246 (2)	4001.6069 (15)	1.7624139 (33)	0.031 (8)	91.9 (1.7)	17.5 (1.5)
OGLE LMC-ECL-20299	79.80 (0.25)	31500 (fixed)	32385 (136)	42.7 (0.4)	46.8 (0.9)	10.5 (1.5)	0.210 (3)	0.216 (2)	4002.8032 (23)	2.8414568 (43)	0.053 (7)	49.9 (2.2)	41.4 (5.0)
OGLE LMC-ECL-20384	83.55 (0.48)	26000 (fixed)	15442 (242)	84.5 (1.1)	15.5 (1.0)	0	0.222 (2)	0.147 (1)	4001.1584 (72)	2.4038316 (129)	0.165 (10)	196.7 (4.1)	54.6 (4.8)
OGLE LMC-ECL-20550	88.83 (0.69)	13000 (fixed)	12758 (138)	55.1 (1.8)	42.5 (3.1)	2.4 (2.4)	0.249 (6)	0.224 (4)	4000.8871 (10)	1.4474212 (5)	0.040 (5)	347.8 (1.0)	13.4 (1.2)
OGLE LMC-ECL-20589	83.75 (0.21)	26000 (fixed)	24274 (226)	54.2 (0.7)	45.8 (0.5)	0	0.195 (3)	0.190 (2)	2926.6720 (133)	3.8535274 (326)	0.195 (33)	207.1 (9.9)	108.8 (4.5)
OGLE LMC-ECL-20648	82.60 (0.15)	17500 (fixed)	18913 (230)	42.3 (0.6)	57.6 (0.8)	0	0.169 (3)	0.186 (3)	4002.2779 (131)	2.5288693 (35)	0.241 (12)	196.5 (7.6)	67.5 (8.2)
OGLE LMC-ECL-20735	83.37 (0.40)	9500 (fixed)	9167 (175)	55.6 (0.4)	44.4 (0.3)	0	0.223 (5)	0.208 (3)	4003.5952 (18)	1.7966394 (23)	0.049 (16)	57.0 (2.4)	58.6 (4.0)
OGLE LMC-ECL-20783	87.99 (0.17)	24000 (fixed)	24253 (120)	46.7 (0.6)	52.3 (0.5)	1.0 (1.0)	0.236 (2)	0.238 (3)	9184.2211 (70)	3.2566811 (80)	0.082 (13)	319.5 (3.5)	60.2 (6.1)
OGLE LMC-ECL-20860	83.87 (0.85)	17000 (fixed)	13737 (191)	33.7 (1.8)	20.9 (2.4)	45.4 (5.6)	0.229 (7)	0.210 (5)	4002.8836 (27)	1.6441828 (33)	0.049 (11)	253.8 (2.2)	22.1 (2.3)
OGLE LMC-ECL-21259	80.40 (0.76)	25500 (fixed)	13838 (334)	54.0 (3.2)	9.1 (2.7)	36.9 (6.1)	0.235 (4)	0.155 (6)	4001.1459 (78)	2.5508208 (251)	0.133 (30)	229.3 (6.0)	73.6 (23.4)
OGLE LMC-ECL-21278	86.90 (0.99)	26000 (fixed)	19842 (342)	62.6 (2.5)	20.7 (0.8)	16.7 (3.7)	0.255 (6)	0.178 (3)	4002.6536 (13)	1.6617522 (27)	0.039 (5)	77.1 (2.6)	31.1 (7.2)
OGLE LMC-ECL-21479	79.09 (0.60)	10400 (fixed)	8006 (207)	69.9 (2.4)	30.1 (2.2)	0	0.211 (6)	0.182 (9)	5550.6183 (99)	2.0602435 (244)	0.177 (41)	160.3 (7.1)	37.7 (8.5)
OGLE LMC-ECL-21647	74.07 (0.21)	17000 (fixed)	17390 (156)	48.9 (0.4)	51.1 (0.4)	0	0.221 (3)	0.221 (3)	4001.3485 (36)	2.6411620 (79)	0.084 (20)	127.6 (4.5)	77.3 (8.7)
OGLE LMC-ECL-21695	81.88 (0.18)	17000 (fixed)	14154 (121)	57.8 (1.0)	42.2 (0.9)	0	0.177 (2)	0.171 (3)	4001.6820 (122)	2.7611224 (396)	0.200 (45)	227.1 (8.4)	154.4 (15.2)
OGLE LMC-ECL-21961	89.74 (0.37)	16000 (fixed)	14973 (218)	56.4 (0.3)	43.6 (0.3)	0	0.194 (2)	0.179 (2)	4001.0849 (42)	2.0607986 (98)	0.096 (6)	296.4 (3.2)	74.3 (5.7)
OGLE LMC-ECL-21968	75.48 (0.71)	24500 (fixed)	29213 (315)	27.9 (0.9)	60.0 (1.3)	12.1 (1.8)	0.175 (3)	0.218 (5)	4001.6143 (31)	2.8824655 (130)	0.150 (52)	79.6 (6.2)	69.6 (30.9)
OGLE LMC-ECL-22069	86.52 (0.27)	31500 (fixed)	29685 (276)	52.9 (1.2)	44.7 (1.4)	2.4 (1.3)	0.174 (4)	0.170 (2)	4000.7189 (49)	2.2719812 (159)	0.210 (31)	135.6 (3.3)	78.1 (15.8)
OGLE LMC-ECL-22211	80.34 (0.40)	16000 (fixed)	13995 (295)	58.1 (0.8)	41.9 (0.8)	0	0.244 (2)	0.228 (3)	4000.8583 (19)	1.3846511 (18)	0.043 (4)	275.8 (1.8)	17.3 (2.0)
OGLE LMC-ECL-22232	80.29 (0.48)	20600 (fixed)	19708 (149)	54.8 (1.4)	30.2 (0.9)	15.0 (3.2)	0.228 (4)	0.176 (3)	4000.7192 (36)	2.0099807 (57)	0.090 (25)	323.2 (4.5)	36.2 (6.6)
OGLE LMC-ECL-22422	85.19 (0.36)	13500 (fixed)	12558 (220)	52.4 (1.1)	47.6 (1.0)	0	0.216 (3)	0.218 (3)	4001.2210 (20)	1.5616800 (46)	0.069 (18)	45.5 (6.1)	43.0 (11.3)
OGLE LMC-ECL-22455	79.54 (0.49)	20600 (fixed)	23856 (478)	22.1 (0.7)	34.8 (0.6)	43.1 (4.5)	0.172 (3)	0.192 (7)	4000.1400 (22)	1.9563996 (37)	0.159 (41)	101.2 (3.2)	67.0 (13.1)
OGLE LMC-ECL-22494	83.08 (0.42)	14000 (fixed)	14492 (298)	41.8 (0.6)	57.8 (0.5)	0.4 (0.4							

Table A.3. Third-body orbit parameters of the individual systems.

System	A [days]	ω_3 [deg]	P_3 [yr]	T_0 [HJD] [2400000+]	e_3	$f(m_3)$ [$M_\odot$]	P^2/P_3 [days]	P_3^2/P [yr]
OGLE LMC-ECL-00483	0.0101 (23)	186.9 (15.1)	16.3 (1.7)	50041 (5400)	0.464 (96)	0.029 (10)	0.0006377	50364
OGLE LMC-ECL-00737	0.0055 (17)	150.0 (18.0)	8.7 (1.1)	51660 (1809)	0.449 (21)	0.014 (3)	0.0012394	13951
OGLE LMC-ECL-02912	0.0054 (12)	76.1 (11.4)	7.9 (1.3)	59187 (239)	0.484 (57)	0.014 (3)	0.0015495	10722
OGLE LMC-ECL-07578	0.0051 (7)	61.6 (12.3)	43.4 (7.4)	51528 (481)	0.450 (103)	0.390 (89)	0.0010190	171095
OGLE LMC-ECL-10302	0.0058 (4)	148.2 (22.1)	6.5 (0.3)	66252 (164)	0.079 (26)	0.025 (2)	0.0010042	9917
OGLE LMC-ECL-11351	0.0121 (9)	244.4 (14.9)	8.7 (0.5)	67153 (872)	0.080 (30)	0.122 (23)	0.0018351	11390
OGLE LMC-ECL-11854	0.0061 (14)	18.1 (23.7)	16.3 (6.6)	57787 (1289)	0.669 (134)	0.010 (24)	0.0009691	40305
OGLE LMC-ECL-12043	0.0114 (18)	130.4 (16.0)	6.1 (0.9)	65487 (578)	0.121 (112)	0.207 (17)	0.0008039	10268
OGLE LMC-ECL-12504	0.0042 (17)	129.1 (24.8)	7.7 (4.0)	55933 (1302)	0.114 (88)	0.006 (4)	0.0020258	9077
OGLE LMC-ECL-12792	0.0138 (24)	26.5 (20.0)	18.7 (1.3)	53958 (375)	0.087 (43)	0.039 (3)	0.0004409	73625
OGLE LMC-ECL-15161	0.0035 (16)	71.4 (18.6)	7.2 (0.8)	65075 (1235)	0.061 (89)	0.004 (2)	0.0050121	5193
OGLE LMC-ECL-15288	0.0065 (10)	256.5 (31.8)	14.2 (3.0)	67590 (772)	0.051 (11)	0.007 (2)	0.0013768	27628
OGLE LMC-ECL-15473	0.0055 (9)	179.4 (10.5)	3.6 (0.2)	65832 (198)	0.077 (23)	0.066 (11)	0.0019212	2977
OGLE LMC-ECL-15664	0.0244 (11)	158.1 (8.2)	4.9 (0.3)	58687 (240)	0.431 (20)	4.123 (127)	0.0018504	4812
OGLE LMC-ECL-15779	0.0118 (23)	192.8 (32.8)	3.4 (0.9)	58062 (181)	0.001 (13)	0.733 (86)	0.0050449	1688
OGLE LMC-ECL-16320	0.0118 (12)	170.1 (7.4)	20.1 (1.3)	62128 (523)	0.372 (82)	0.027 (6)	0.0006066	69760
OGLE LMC-ECL-16414	0.0199 (16)	28.8 (18.2)	12.8 (2.5)	69372 (526)	0.069 (14)	0.252 (72)	0.0010706	26940
OGLE LMC-ECL-16928	0.0108 (24)	94.3 (11.1)	16.6 (4.1)	67522 (820)	0.094 (32)	0.024 (18)	0.0013116	35643
OGLE LMC-ECL-17183	0.0060 (9)	166.3 (10.9)	10.1 (2.7)	67869 (533)	0.069 (13)	0.011 (5)	0.0013146	17029
OGLE LMC-ECL-17198	0.0102 (17)	191.3 (8.4)	2.9 (0.3)	89367 (114)	0.599 (65)	1.218 (79)	0.0100834	959
OGLE LMC-ECL-17236	0.0079 (10)	305.5 (15.2)	8.4 (3.7)	49564 (1270)	0.317 (115)	0.037 (12)	0.0008057	16493
OGLE LMC-ECL-17267	0.0517 (110)	300.3 (20.1)	42.9 (8.9)	85049 (1431)	0.749 (143)	0.490 (139)	0.0002257	357586
OGLE LMC-ECL-17498	0.0042 (9)	209.4 (16.0)	10.2 (2.2)	65941 (418)	0.188 (72)	0.004 (1)	0.0018049	14573
OGLE LMC-ECL-17579	0.0193 (22)	56.8 (17.4)	7.8 (0.6)	65679 (172)	0.187 (14)	0.631 (19)	0.0008424	14321
OGLE LMC-ECL-17774	0.0409 (26)	10.4 (10.2)	11.1 (1.1)	52695 (370)	0.378 (72)	3.605 (82)	0.0037569	11456
OGLE LMC-ECL-17800	0.0055 (11)	251.4 (32.7)	14.8 (2.4)	67039 (696)	0.203 (83)	0.004 (2)	0.0003806	55890
OGLE LMC-ECL-18355	0.0118 (16)	359.9 (11.6)	4.9 (1.0)	64531 (389)	0.226 (68)	0.392 (90)	0.0026393	4002
OGLE LMC-ECL-18579	0.0062 (23)	194.6 (22.5)	9.3 (1.8)	63356 (665)	0.211 (110)	0.016 (9)	0.0028625	10123
OGLE LMC-ECL-19583	0.0057 (17)	358.3 (10.1)	7.9 (1.1)	64448 (402)	0.126 (60)	0.016 (3)	0.0016531	10515
OGLE LMC-ECL-19879	0.0096 (8)	253.3 (8.9)	7.0 (0.5)	58977 (211)	0.747 (101)	0.101 (66)	0.0056815	4629
OGLE LMC-ECL-20053	0.0033 (11)	236.1 (21.8)	5.6 (1.0)	67592 (326)	0.209 (93)	0.006 (3)	0.0017783	6003
OGLE LMC-ECL-20299	0.0039 (7)	112.3 (10.4)	9.7 (1.6)	63550 (501)	0.141 (76)	0.003 (2)	0.0022804	12180
OGLE LMC-ECL-20860	0.0437 (9)	1.4 (8.5)	19.7 (0.8)	63450 (234)	0.107 (13)	1.143 (15)	0.0003763	85949
OGLE LMC-ECL-21968	0.0063 (11)	355.7 (12.8)	3.7 (0.7)	54143 (290)	0.750 (109)	0.322 (77)	0.0060234	1762
OGLE LMC-ECL-22232	0.0049 (8)	3.7 (13.0)	8.8 (1.6)	55716 (498)	0.749 (152)	0.027 (11)	0.0012493	14245
OGLE LMC-ECL-22613	0.0449 (12)	189.2 (3.7)	23.5 (0.4)	57134 (141)	0.521 (21)	1.344 (48)	0.0003709	113408

Fig. A.1. Light curves.

Fig. A.1. continued.

Fig. A.1. continued.

Fig. A.1. continued.

Fig. A.1. continued.

Fig. A.1. continued.

Fig. A.2. $O - C$ diagrams.

Fig. A.2. continued.

Fig. A.2. continued.

Fig. A.2. continued.

Fig. A.2. continued.

Fig. A.2. continued.

Fig. A.3. $O - C$ diagrams after subtraction of apsidal motion fits. The LTE variations are plotted as red curves.

Fig. A.4. $O - C$ diagrams after subtraction of apsidal motion fits for cases where there appears to be some variation of residuals, but it is still rather questionable. More data are needed.