Period Changes of LMC Cepheids in the OGLE and MACHO Data

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ABSTRACT

Pulsation period of Cepheids should change as stars evolve through theinstability strip. Rates of these changes found by other authors based on the decades-long $O-C$ diagrams show rather good agreement with theoretical predictions. We have checked the variability on the scale of a few years on the data recently published by the Optical Gravitational Lensing Experiment (OGLE) for the Large Magellanic Cloud Cepheids and found period changes for 18% of fundamental mode and 41% of first overtone pulsators. It suggest the overtone pulsations are less stable than the fundamental ones. For stars which had the cross-references in the MACHO catalog we have checked if the period change rates derived from the OGLE and the MACHO data are consistent. It was found that there is no correlation and opposite signs of changes in both data sets are more common than the same ones. Many $O-C$ diagrams show nonlinear period changes similarly as for some stars the diagrams derived from the OGLE data only (spanning up to 4100 days) show random fluctuations. These fluctuations are common on the long-term $O-C$ diagrams and we conclude they dominate the diagrams for the timescales of a few thousand of days. The distributions of periods and colors for all Cepheids and for those with statistically significant period changes are the same. Times of maximum light obtained using the MACHO and the OGLE data as well as the examples of $O-C$ diagrams are presented.

Key words: Stars: oscillations – Cepheids – Magellanic Clouds

1. Introduction

Stars with masses higher than a few solar masses after main sequence phase may cross the Cepheid instability strip in the Hertzsprung–Russell diagram. Then, such a star becomes unstable to radial pulsations and can be observed as a Cepheid. Detailed investigation on the Cepheid pulsation properties can give constrains for stellar pulsation and evolution theories. That is especially true for objects caught during the first crossing of the instability strip i.e., while being in the Hertzsprung gap.

1Based on observations obtained with the 1.3 m Warsaw telescope at the Las Campanas Observatory of the Carnegie Institution of Washington.
Cepheids should change periods during each crossing of the instability strip with the positive sign of the period change rate for odd and negative for even crossings. Theoretically predicted timescales of period changes ($P/\dot{P}$) are between $10^4$ and $10^7$ years and should be measurable on a few decades long $O-C$ diagrams (see e.g., Zhou 1999 for a review). For some stars there are times of maximum light observed for more than 100 years and detailed $O-C$ diagrams can be constructed. In this traditional method data obtained by different observers using different telescopes, filters and light detectors are used. The results of such investigations were shown e.g., by Berdnikov (1994), Berdnikov and Pastukhova (1994), Berdnikov et al. (1997) and Berdnikov et al. (2004). They show generally good agreement with evolutionary predictions (Turner et al. 2006).

The second method for measuring period changes is to compare periods found in two distant epochs (e.g., Pietrukowicz 2001, 2002, Bird et al. 2008). One assumes the period change rate is constant or nearly constant and divides the difference of periods by the time difference of two epochs obtaining period change rate. If only one such value is estimated for each Cepheid there is no way to verify if the assumption of constant period change rate is true and all the results are uncertain. Deasy and Wayman (1985) used 3 epochs separated by $\approx 44$ and $\approx 10$ years. They found about half of Cepheids to have variable rate of period changes.

One can use another method – assume trial period $P$ and its change rate $\dot{P}$, fold the data and evaluate some statistic to check if $P$ and $\dot{P}$ were chosen properly. Extreme of this statistic should yield correct $P$ and $\dot{P}$ values (e.g., Kubiak et al. 2006, Pilecki et al. 2007). In this method one also assumes constant period change rate. The way to check if it is true can be a comparison of the scatter in data folded using estimated $P$ and $\dot{P}$ with photometric uncertainties. Data used in that method should be transformed to the standard system, if they were obtained with different telescopes or detectors.

In this work we rely on the Optical Gravitational Lensing Experiment (OGLE) data. OGLE is a long-term wide-field microlensing survey. As a by-product huge amount of homogeneous photometric data are obtained. Thus, the last method described above can be used. Theoretically predicted Cepheids period changes (Turner et al. 2006) should cause big enough phase shift since the beginning of the OGLE-II in January 1997 for all first crossing Cepheids to be detectable. It is also true for the Cepheids with long periods during the second and the third crossing.

Soszyński et al. (2008) published first part of the OGLE-III Catalog of Variable Stars (OIII-CVS) which presents data for over 3000 single mode Cepheids in the Large Magellanic Cloud (LMC). The accuracy of the period change rate determination increases as a square of time base of observations, so we decided to use also the MACHO data which cover years 1992–1999. Longer time-base give opportunity to check period change rate variations.
In Section 2 we describe the photometric data and the methods used in present analysis. The results are shown in Section 3 and their discussion is given in Section 4. For convenience we refer O2 and O3 to the stars for which the OGLE-II data do and do not exist. For all analyzed stars the OGLE-III data are available.

2. Data and Methods

The OGLE data have been collected with the 1.3-m Warsaw telescope located at the Las Campanas Observatory. The camera is an eight chip SITE 2048 × 4096 CCD mosaic. Each pixel is 15 µm and corresponding scale is 0.26 arcsec/pixel. Full description of the setup was given by Udalski (2003). The Difference Image Analysis (Alard and Lupton 1998, Alard 2000, Woźniak 2000, Udalski et al. 2008) was used to obtain the photometry. Most of observations are taken through the I filter and only these data are used in this work. The OGLE-II and OGLE-III data for each Cepheid were tied by Soszyński et al. (2008). Before our analysis was started we manually removed all the outlying points from the OIII-CVS photometry.

The MACHO photometric data (Allsman and Axelrod 2001) were collected with the 50-inch Great Melbourne Telescope located at the Mount Stromlo Observatory. The dichroic element coupled to the telescope allowed simultaneous observations in two nonstandard filters centered at 560 and 710 nm called \( V_M \) and \( R_M \), respectively. Each camera consisted of four Loral 2096 × 2096 CCD chips. The scale was 0.62 arcsec/pixel. The PSF photometry was obtained using SoDoPHOT software. Details were published by Hart et al. (1996) and Alcock et al. (1999).

We included only these MACHO Cepheids for which there were cross-references given by Soszyński et al. (2008). Significant number of the MACHO data points were outlying. All points with error estimations higher than 0.1 mag were removed. All points deviating from the average by more than three times the dispersion were iteratively removed from the light curves. Finally, Fourier series were fitted to the data and 3\( \sigma \) clipping procedure was applied. We checked by eye if the last procedure have not removed points on the rising branch with steep slope. Several times we decided to restore removed points. Stars with less than 100 photometric points were removed. The whole procedure was conducted separately for the \( V_M \) and \( R_M \) data.

We have taken the single mode fundamental (F) and first overtone (1O) classical Cepheids from the OIII-CVS. Objects with additional periodicities, mean brightness variability as well as ones with poor phase-coverage near maximum light (mainly due to small number of data or period close to integer number of days) were removed. The period given there \( (P_C) \) for each object was used as starting value for our calculations. Table 1 summarizes number of stars in different data sets. We had on average 754, 384, 843 and 988 photometric points spanning 3920, 2370, 2680 and 2700 days for O2, O3, MACHO \( R_M \) and MACHO \( V_M \) data, respectively.
Table 1
Number of stars in different data sets for fundamental (F), first overtone (1O) and both pulsation modes together

|       | O2 | RM | VM | M  | O2 & RM | O2 & VM | R & M  | O2 & R & M |
|-------|----|----|----|----|---------|---------|--------|------------|
| F     | 1785 | 750 | 934 | 933 | 513 | 512 | 928 | 509 |
| 1O    | 1161 | 510 | 575 | 571 | 327 | 323 | 570 | 323 |
| F or 1O | 2946 | 1260 | 1509 | 1504 | 840 | 835 | 1498 | 832 |

All objects are present in OGLE-III data. RM and VM stands for the MACHO RM and VM filter data.

2.1. O–C Method

The data obtained by the sky surveys such as OGLE are hard to use in traditional $O - C$ analysis. Typical cadence is one measurement per night and only for the longest period Cepheids more than 10 points are obtained during one cycle and traditional method of maximum time determination can be applied. One can fold points from longer period of time and find $O - C$ value using Hertzsprung method (Berdnikov 1992) instead, i.e., by shifting the phase of mean light curve to minimize the sum of squared differences between the observed brightness and the mean light curve. The mean light curve was constructed by fitting Fourier series with the number of terms set between 4 and 12 and chosen for each star separately to minimize $\chi^2$ per degree of freedom. The terms with coefficients smaller than 3 times their errors were neglected.

If a star changes its period rapidly then several years long data can show high scatter when folded with the best constant period. To avoid this problem we first folded the light curve with $P_C$ and $\dot{P} = 0$ and calculated one $O - C$ value for each observing season. If there was evidence for high period change rate on the resulting $O - C$ diagram we calculated $P_0$ and $\dot{P}_0$ determined from each data set separately from the parabolic fit. These values were used to obtain the new light curve and the new Fourier fit.

In the final stage we divided the data from each observing season into chunks. The number of data points in each observing season was divided by 10 for OGLE and 20 for MACHO data. Number of chunks for a given observing season was equal to the integral part of the result. Each chunk contained consecutive points which number was from 10 to 19 for the OGLE data and from 20 to 39 for the MACHO data. Each chunk was used to find one $O - C$ value. The significance of parabolic term in the least squares fit to the resulting $O - C$ diagram was checked using the F-test (Pringle 1975) with 1% significance level and from the parabolic
fit the values $P_1$ and $\dot{P}_1$ were found. For stars with high amplitude variations not only the phase was shifted but also the relative amplitude was fitted for each chunk.

### 2.2. Fourier Fitting

In the second method used to search for period changes data were folded according to the trial period $P$ and its change rate $\dot{P}$. Then, Fourier series was fitted to the folded light curve and $\chi^2$ was calculated. The trial values $P_2$ and $\dot{P}_2$ which minimize $\chi^2$ were found using the simplex method (Press et al. 1992). The Fourier fitting was performed in the same way as in the $O-C$ method. The procedure of fitting Fourier series is linear and thus it is much easier to perform. Only two parameters ($P$ and $\dot{P}$) were fitted by the simplex method. If the $O-C$ method showed significant period change for a given star then values $P_1$ and $\dot{P}_1$ were also used as starting points for simplex. Errors in $\dot{P}$ were evaluated by 1000 iterations of
Monte Carlo simulations. We empirically found they do not depend on $\dot{P}$ assumed for the simulation. Henceforth, $3\sigma$ criterion was applied to check significance of $\dot{P}$. Pilecki et al. (2007) proposed that estimation of the minimum error of period change rate ($\sigma_{est}$) for a star with the sinusoidal light curve observed $N$ times uniformly distributed over time $T$ can be given by

$$\sigma_{est} \approx \frac{12P_{sin}^2}{N^{1/2}T^2} \cdot \frac{\sigma}{A}$$  

(1)

where $\sigma$ is photometric error, $P_{sin}$ - period of a sinusoid (not to be confused with orbital period of a binary used by Pilecki et al. 2007) and $A$ – full-amplitude. Fig. 1 shows the ratio of this estimation and values found by the Fourier fitting for the OGLE data ($\sigma_2$) as a function of period separately for F and 1O Cepheids. Values of $A$ and $\sigma$ were found using the light curves folded with $P_2$ and $\dot{P}_2$. The points with high values correspond to stars with periods close to integer number of days or those with large gaps in data. The difference between F and 1O pulsators and change of this ratio with period are caused by changes in the light curve shape (cf. Fig. 1 in Soszyński et al. 2008). Brightness of the longest period Cepheids changes very rapidly on rising branch and a small period change causes big changes between brightness predicted with assumption of constant period and true one. Thus, some objects may have $\sigma_2$ much smaller than $\sigma_{est}$. The same figure for MACHO data is very similar, although they have smaller seasonal gaps and the data are distributed more uniformly. We conclude that the above estimation can be used to check what accuracy of the period change rate can be achieved with given data.

2.3. Comparison of Methods

For the OGLE data exactly the same number of changing period Cepheids was found using each of the methods (803 i.e., 27% of the sample). However, out of them only 655 objects where found using both methods which is 22% of the sample and 69% of Cepheids with period changes found using either method. The only case for which the period change rates have opposite signs was OGLE-LMC-CEP-2176, which is close to the saturation limit of the OGLE photometry. The results from two methods for another 33 out of 655 Cepheids were inconsistent in the meaning of the $3\sigma$ limit, in most cases due to some additional variability on the $O-C$ diagrams.

Evolutionary models predict that the period change rates for the first crossing Cepheids are at least two times larger at given period than for the third crossing Cepheids (Turner et al. 2006) with $\log P < 1.1$ (98% of our sample). Fig. 2 compares the timescales of period changes derived from the OGLE data using both methods described in the Sections 2.1 and 2.2. Comparison of the MACHO $R_M$ and $V_M$ results from the Fourier fitting method shows the same signs and very similar rates for all objects. These findings ensure that the methods are sufficient to distinguish between evolutionary changes caused by different crossings of the instability strip.
Fig. 2. Comparison of period derivatives found on OGLE data for 655 Cepheids using two different methods.

3. Results

Fourier fitting analysis of the OGLE data showed period changes for 18% fundamental mode and for 41% first overtone Cepheids. Logarithm of the timescales of period changes (log $|P_2/\dot{P}_2|$) as a function of the logarithm of period is shown in Figs. 3 and 4 for F and IO pulsators, respectively. Solid lines mark theoretical predictions for the first, second and third crossing of the instability strip taken from Turner et al. (2006). Dash-dotted lines show thermal timescales (equal to $GM^2/RL$ where $G$ is gravitational constant, $M$ – mass of the star, $R$ – its radius and $L$ – luminosity) evaluated on the basis of Alibert et al. (1999) models for the LMC metallicity. The number of objects falling in the first crossing regions is striking. The time spent in the Hertzsprung gap is so short that one per around a hundred Cepheids should be caught during that phase of stellar evolution. We do not know any confirmed first crossing Cepheid, last candidates being Polaris and DX Gem (Turner et al. 2006), two LMC triple mode Cepheids (Moskalik and Dziembowski
Fig. 3. Timescales of period change rates for fundamental mode Cepheids derived from OGLE data using Fourier fitting. Upper and lower panels show positive and negative period changes, respectively. Solid lines mark regions within which theoretically predicted (cf. Turner et al. 2006) evolutionary period changes for different crossings of the instability strip should be found: thick lines mark the first crossing region, thin lines mark the second and the third crossing region. Lines end in the same points as in Fig. 2 in Turner et al. (2006). Dotted lines show linear fit to detection limits for O2 (observed by OGLE-II and OGLE-III) and dash lines for O3 (observed by OGLE-III and not observed by OGLE-II) stars. Dash-dotted lines show thermal timescale.
Fig. 4. Similar to Fig. 3 for 1O pulsators. Theoretical predictions are the same. For the second and the third crossing regions only the lower limits are shown. Thermal timescale was shifted by $-0.125$ in $\log(P)$.

2005), shortest period Cepheids ($P < 1.7$ d for LMC; cf. Alibert et al. 1999 Table 7) and almost all 1O/2O Cepheids (Baraffe et al. 1999). Moreover, there are stars with the same timescale of period changes as for the first crossing, but with negative $\dot{P}$ what is in conflict with the evolutionary predictions. In fact, in both of these figures
the distribution of points is the same for positive and negative period changes. Also the period and \((V-I)\) color (Fig. 5) distributions of F and 1O Cepheids are the same for whole sample and stars with significant period changes.

**Fig. 5.** Distributions of \(V-I\) color for F (top) and 1O (bottom panel) Cepheids. Distributions for all Cepheids in a given mode are shown by solid lines and for changing period ones with dashed lines.

Table 2 shows the incidence rates of period changing Cepheids. Errors were calculated assuming Poisson distribution of the number of Cepheids with period changes. In all cases first overtone pulsators show period changes more often than the fundamental mode ones, with the average ratio of incidence rates equal to 2.7. Timescales for 1O also group closer to thermal timescale than for F Cepheids (Figs. 3 and 4). It may be interesting to compare these values with the incidents rate of Blazhko Cepheids: 4\% for F and 28\% for 1O (Soszyński et al. 2008). Both results suggest higher instability of the first overtone oscillations. For all data sets
Table 2

Percentage of all ($p$), positive ($p_+$) and negative ($p_-$) period changes in different data sets

| Data set   | Puls. mode | $p$    | $p_+$  | $p_-$  |
|------------|------------|--------|--------|--------|
| OGLE       | F          | 18.1 ± 0.9% | 8.9 ± 0.7% | 9.2 ± 0.7% |
| OGLE       | 1O         | 41.3 ± 1.4% | 21.9 ± 1.2% | 19.5 ± 1.2% |
| MACHO $R_M$| F          | 11.1 ± 1.0% | 4.0 ± 0.6% | 7.2 ± 0.8% |
| MACHO $R_M$| 1O         | 36.9 ± 2.0% | 16.2 ± 1.5% | 20.7 ± 1.7% |
| MACHO $V_M$| F          | 15.0 ± 1.2% | 5.6 ± 0.8% | 9.4 ± 1.0% |
| MACHO $V_M$| 1O         | 43.8 ± 2.1% | 19.8 ± 1.7% | 24.0 ± 1.8% |
| average    | F          | 15.0 ± 0.7% | 6.0 ± 0.4% | 8.6 ± 0.5% |
| average    | 1O         | 40.8 ± 1.1% | 19.7 ± 0.9% | 20.8 ± 0.9% |

and modes, except for the OGLE data for first overtone pulsators, the negative period changes are more common than the positive ones. We found the observational errors in $\dot{P}$ to be $\approx 1.3$ times larger for 1O than for F Cepheids what is caused mainly by smaller amplitude of 1O. As a consequence the observational limit in $\log |\dot{P}/P|$ is smaller for 1O. For stars with significant period changes the average modulus of $\dot{P}/\sigma_\dot{P}$ is equal to $7.3 \pm 0.5$ for F and $11.1 \pm 0.6$ for 1O pulsators.

The period changes have the same signs for 23 of F (53 of 1O) and opposite for 36 (87) Cepheids when comparing OGLE and MACHO $R_M$ Fourier fitting results. OGLE and MACHO $V_M$ give 24 (65) the same and 48 (100) opposite results, respectively.

Table 3

Sample part of list.dat file

| Cepheid ID     | $P$ [d]  | $\sigma_P$ [d] | Puls. mode | Remarks |
|----------------|---------|---------------|------------|---------|
| OGLE-LMC-CEP-0771 | 2.1516256 | 0.0000017 | 1O | V,R,O |
| OGLE-LMC-CEP-0772 | 3.0735245 | 0.0000019 | F | V,R,O |
| OGLE-LMC-CEP-0773 | 4.1847753 | 0.0000052 | F | V,R |
| OGLE-LMC-CEP-0774 | 3.1233001 | 0.0000177 | 1O |       |
| OGLE-LMC-CEP-0775 | 1.8634008 | 0.0000061 | 1O |       |
| OGLE-LMC-CEP-0776 | 6.8937966 | 0.0000062 | F | O |
| OGLE-LMC-CEP-0777 | 2.9979476 | 0.0000043 | F |       |
| OGLE-LMC-CEP-0778 | 3.0904206 | 0.0000013 | F | V,R,O |
| OGLE-LMC-CEP-0779 | 2.5607125 | 0.0000014 | F | O |
| OGLE-LMC-CEP-0780 | 3.8269168 | 0.0000035 | F | V,R |
Using previously determined $O-C$ values we calculated times of maximum light for each star. These data are available from the Internet archive:

[ftp://ftp.astrouw.edu.pl/ogle/ogle3/OIII-CVS/lmc/cep/max_time/](ftp://ftp.astrouw.edu.pl/ogle/ogle3/OIII-CVS/lmc/cep/max_time/)

The list of analyzed Cepheids is given in file list.dat and contains OIII-CVS ID, mean period and its error, pulsation mode and remarks which may be: $V$, $R$, $O$, if MACHO $V_M$, MACHO $R_M$ and OGLE-II maxima were calculated, and $A$ if the amplitude was variable in at least one of the data sets. Mean periods were determined for each of the data set separately using software TATRY (Schwarzenberg-Czerny 1996). The MACHO periods were then averaged and resulting values were averaged with the OGLE periods to obtain mean periods. The application of other periods for construction of the $O-C$ diagram is also possible, but would cause very high or very low $O-C$ values making visual inspection harder and in extreme cases leading to wrong interpretation.

| HJD of maximum light | Error  | Source |
|----------------------|--------|--------|
| 2450835.3347         | 0.0065 | O      |
| 2450847.6335         | 0.0081 | O      |
| 2450866.0462         | 0.0056 | V      |
| 2450872.2166         | 0.0063 | O      |
| 2450875.2750         | 0.0102 | R      |
| 2450912.1596         | 0.0185 | O      |
| 2451053.5473         | 0.0123 | V      |
| 2451078.1476         | 0.0069 | O      |
| 2451096.5588         | 0.0136 | R      |
| 2451111.9331         | 0.0050 | O      |

Files OGLE-LMC-CEP-NNNN.max, where NNNN stands for the OIII-CVS catalog number, contain in consecutive columns: time of maximum light (HJD), its error (days) and data source identification ($O$, $R$ and $V$ for OGLE, MACHO $R_M$ and MACHO $V_M$, respectively). Tables 3 and 4 present sample parts of list.dat and one of the OGLE-LMC-CEP-NNNN.max files. Calculated differences of times of maximum light are reliable for each data source but may be subject to the shifts in zero points of up to 0.1 day. They may be caused by different times of maximum light in different filters or imperfections in fitting and finding maximum of the Fourier series. Similar differences are found in the traditional $O-C$ diagrams (e.g., Berdnikov and Pastukhova 1994 and their Table 3). Also analysis of the data for 671 Cepheids for which we have MACHO times of maximum light, but we
do not have the OGLE-II ones, has to be done with caution in view of a possible epoch counting error. Presented data may be added to the existing $O-C$ diagrams and/or tested for presence of random fluctuations using methods described e.g., by Lombard (1998) or Berdnikov et al. (2004).

![Fig. 6. Exemplary $O-C$ diagrams for the LMC Cepheids. Filled triangles, crosses and open circles correspond to MACHO $R_M$, MACHO $V_M$ and OGLE data, respectively. OIII-CVS ID and rounded period (days) are given above each panel. The abscissa is common for all panels, the ordinate is given on left or right of each panel. OGLE-II and OGLE-III data start at 460 or 740 and 2200, respectively. MACHO data end at 1500. No filter dependent shifts for the $O-C$ values were applied. OGLE-LMC-CEP-1742 and OGLE-LMC-CEP-1861 are examples of Cepheids changing period in opposite directions in the OGLE and MACHO data.](image)

Figs. 6 and 7 show examples of the $O-C$ diagrams for Cepheids with de-
OGLE-LMC-CEP-1932 shows nonlinear period changes even though only OGLE data are used. OGLE-LMC-CEP-2196 is one of the stars which are subject to epoch counting error. O – C diagram of OGLE-LMC-CEP-3149 shows changes with quasi-period ≈ 1570 d long.

Fig. 7. Same as Fig. 6. OGLE-LMC-CEP-1932 shows nonlinear period changes even though only OGLE data are used. OGLE-LMC-CEP-2196 is one of the stars which are subject to epoch counting error. O – C diagram of OGLE-LMC-CEP-3149 shows changes with quasi-period ≈ 1570 d long.

determined period changes. Visual inspection of all constructed O – C diagrams revealed that there may be only a few out of 1515 Cepheids observed by MACHO and OGLE that show parabolic diagrams without any additional variability. OGLE-LMC-CEP-1119 (LMC_SC11-338308) was one of the first overtone Cepheids analyzed by Moskalik and Kołaczkowski (2008). The impression one may have after examination of their phase variation graphs is that the phases change in parabolic or sinusoidal way. The O – C diagram for OGLE-LMC-CEP-1119 presented in Fig. 6 clearly shows that this statement is not always true. We also found period
changes for four 1O Cepheids for which they found amplitude changes only. We confirmed period changes for other first overtone Cepheids listed by Moskalik and Kołaczkowski (2008, Table 4).

4. Summary and Conclusions

We have used two different methods to find period changes of single mode Cepheids. Both gave similar results. Numerical test proved that Pilecki et al. (2007) error estimation method works well for sinusoidal light curves and is sufficient for other objects.

Positive and negative period changes show the same dependence on period (Figs. 3 and 4) with very short timescales of these changes. The sample of Cepheids changing period shows the same distribution of periods and \((V - I)\) colors as all Cepheids pulsating in the same mode. 1O Cepheids were found changing period 2.7 times more often than the F pulsators. The timescales of the found period changes group closer to thermal timescale for 1O than for F pulsators. Since we have found only some random effects, not the evolutionary ones, we suspect the F pulsation periods to be more stable than the 1O ones. Period change rates have opposite signs more often than the same signs in the MACHO and OGLE data which partly overlap. It may be a result of some random changes which typical duration is a few thousand days. Decades long \(O - C\) diagrams show similar changes (Berdnikov 1994, Berdnikov and Pastukhova 1994, Berdnikov et al. 1997, Berdnikov et al. 2004) and we conclude that they dominate \(O - C\) diagrams for short time base – up to 30–40 years. This effect also affects periods derived from a few thousand day long survey and hence period change rates found by Pietrukowicz (2001, 2002) do not reflect the evolutionary changes only. Our results show how difficult is exact period change rate determination. The way in which the found period changes are connected to Blazhko effect is subject for further analysis.

Another problem arises for double or triple mode pulsators. The period change rates can have opposite signs or different and changing rates (Moskalik and Kołaczkowski 2008), thus simple application of Fourier fitting with constant and equal in each mode timescale of these changes may cause spurious results as probably was the case for Moskalik and Dziembowski (2005) triple mode Cepheids for which seismic models suggested these objects are in the Hertzsprung gap.

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