

Galactic Cepheids. Catalogue* of light-curve parameters and distances

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Abstract. We report a new version of the catalogue of distances and light-curve parameters for Galactic classical Cepheids. The catalogue lists amplitudes, magnitudes at maximum light, and intensity means for 455 stars in *BVRI* filters of the Johnson system and $(RI)_C$ filters of the Cron–Cousins system. The distances are based on our new multicolour set of PL relations and on our Cepheid-based solution for interstellar extinction law parameters and are referred to an LMC distance modulus of 18.25.

Key words: Cepheids

363 fundamental-mode pulsators and proved to be a very useful tool for the study of the distribution and kinematics of Cepheids in the Milky Way (Berdnikov 1987c; Berdnikov & Bogdanov 1989; Berdnikov & Efremov 1989, 1993; Dambis et al. 1995; Mishurov et al. 1997; Berdnikov et al. 1998; Glushkova et al. 1998). Since the publication of this catalogue we have collected extensive photoelectric data which, combined with published photometry, allows us to increase the number of stars with reliable light curves by ~ 25 per cent. This, and also the fact that we recently refined some of the fundamental underlying assumptions and procedures used to calculate the Cepheid distances, namely interstellar extinction law (Berdnikov et al. 1996a) and PL relation (Berdnikov et al. 1996b), made it necessary to prepare a new version of our catalogue, which we present in this paper.

1. Introduction

In 1981 we started our long-term program of regular photoelectric photometry of Galactic classical Cepheids. By now we have already obtained a total of more than 35 000 measurements in the *UBV(RI)_C* system for almost 500 objects both in the Northern and Southern sky. Most of our observations have been published by Berdnikov (1986, 1987b, 1992a–g, 1993), Berdnikov & Turner (1995a,b, 1998a,b), Berdnikov & Vozyakova (1995), Berdnikov et al. (1998) and Vozyakova & Ignatova (2000). All our observations (including the unpublished ones) are available in the INTERNET at:

[ftp.sai.msu.su/pub/groups/cluster/cepheids/](ftp:sai.msu.su/pub/groups/cluster/cepheids/)

Earlier (Berdnikov 1987a) we used our observations, in combination with those published by other authors, to determine distances and light-curve parameters for Galactic classical Cepheids with available photoelectric photometry in the *BVRI* filters of the Johnson system and $(RI)_C$ filters of the Cron–Cousins system. The resulting catalogue (Berdnikov 1987a) contained homogeneous data for

2. Light-curve parameters

In our previous work (Berdnikov 1987a) we derived the Cepheid light-curve parameters only for photometric passbands *UBVRI* of the Johnson system and reduced all observations taken in the $(RI)_C$ filters of the Cron–Cousins system to *RI* magnitudes. However, in this version of the catalogue we give separate light-curve parameters for $(RI)_C$ passbands because they are now extensively used in the photometry of both galactic and extragalactic Cepheids. We also dropped the *U* magnitude from our catalogue because it is now not used in the Cepheid photometry. We have published a catalogue of infrared (*JHK*) light-curve parameters elsewhere (Berdnikov et al. 1996a).

To derive light-curve parameters in the *UBVRI(RI)_C* filters we first selected for each Cepheid and filter the observations that most accurately outlined the shape of the light curve. In most of cases these were either our own observations or those of Gieren (1981), Dean et al. (1977), Coulson & Caldwell (1985), Moffet & Barnes (1984), and Pont et al. (1997) whose photometric systems are virtually identical to our own. We then fitted the light curve,

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* The catalogue is only available in electronic form at the CDS via anonymous ftp (130.79.128.5) or via <http://cdsweb.u-strasbg.fr/Abstract.html>

either on the entire $[0, 1]$ phase interval or on its subintervals, by a Fourier series (with 3 to 25 terms), a spline, or a second-to-third-order polynomial and joined the resulting fragments to obtain the so-called master light curve. We then used the linear least squares technique to reduce all other observations to the photometric system of the master curve (a detailed description of the algorithm can be found in Berdnikov 1992g) with subsequent refinement of the initial master curve based on all available observations. We used the final master curve to determine the principal parameters of the light-curves: magnitude at maximum light, amplitude, and intensity-mean magnitude.

Reduction of $\sim 80\,000$ observations in our Cepheid data bank (Berdnikov 1995) yielded reliable and accurate light curves for 455 Cepheids compared to 363 stars in the previous version of the catalogue (Berdnikov 1987a).

3. Distances

We inferred the distances to Cepheids using the light-curve parameters derived as described above and the following procedure suggested by Berdnikov et al. (1996b):

(1) We use the period-colour relation by Dean et al. (1977) to determine the intrinsic colour, $(\langle B \rangle - \langle V \rangle)_0$, and the colour excess:

$$E_{B-V} = (\langle B \rangle - \langle V \rangle) - (\langle B \rangle - \langle V \rangle)_0.$$

In the absence of accurate $\langle B \rangle$ magnitude we first determine the intrinsic colour $(\langle V \rangle - \langle m_\lambda \rangle)_0 = \langle M_V \rangle - \langle M_\lambda \rangle (\log P)$ using PL relations $\langle M_V \rangle (\log P)$ and $\langle M_\lambda \rangle (\log P)$ from Berdnikov et al. (1996b). We then calculate the corresponding colour excess E_{V-m_λ} and convert it into E_{B-V} using interstellar extinction law parameters from Berdnikov et al. (1996a,b).

(2) If the mean magnitude, $\langle K \rangle$, is not available directly from observations, it is derived from formula (5) or an appropriate formula from Table 7 in Berdnikov et al. (1996b) based on known $\langle V \rangle$ and $\langle m_\lambda \rangle$. Here m_λ can be any of the B , R , I , R_C , or I_C filters. The galactocentric distance of the star, which is required to allow for the abundance gradient in the disk, is calculated from the preliminary heliocentric distance inferred from $\langle B \rangle$, $\langle V \rangle$, and $\log P$. To this end, we use PL relation of Berdnikov & Efremov (1985) and adopt $R_0 = 7.1$ kpc, where R_0 is the distance of the Sun from the Galactic centre. Note that we derived the formulas used to infer $\langle K \rangle$ from, say, $\langle B \rangle$, $\langle V \rangle$, $\log P$, and $R_g - R_0$ without adopting any specific value for the abundance gradient in the galactic disk. Each of these formulas simply establishes a relation between two observed colours (e.g., $\langle V \rangle - \langle K \rangle$ and $\langle B \rangle - \langle V \rangle$), the period, P , and the difference of galactocentric distances of the star (R_g) and the Sun (R_0). The coefficients at $R_g - R_0$, if combined with some relation connecting abundance differences into colours, can be used to estimate the abundance gradient.

(3) $\langle K \rangle$ is then corrected for interstellar extinction: $\langle K \rangle_0 = \langle K \rangle - 0.274 \cdot E_{B-V}$.

(4) The absolute magnitude of a star is then determined from the following formula:

$$\langle M_K \rangle = -5.462 - 3.517 \cdot (\log P - 1).$$

(5) The true distance modulus is then calculated as:

$$DM_0 = \langle K \rangle_0 - \langle M_K \rangle.$$

(6) And, finally, the distance r_{hel} (in kpc) is given by: $r = 10^{0.2 \cdot (DM_0 - 10)}$.

The distances thus derived are on a short distance scale consistent with an LMC distance modulus of 18.25 (Berdnikov et al. 1996b).

3.1. The catalogue

The resulting light-curve parameters and distances of 455 Galactic classical Cepheids are summarised in the table. The first column of the table gives the name of the Cepheid; the second column, its variability type according to GCVS (Kholopov et al. 1985–1987). The third column gives the fundamental period P_0 , which is equal to the observed variability period for most of the Cepheids (DCEP or CEP type in GCVS). We assumed that small-amplitude Cepheids (DCEPS type in GCVS) are first-overtone pulsators and therefore calculated their fundamental periods by dividing the GCVS value by a factor of $0.716 - 0.027 \cdot \log P$ as found by Alcock et al. (1995) and slightly modified by Feast & Catchpole (1997). Note that we give P_0 only up to the second digit after the decimal point to save the space because this precision is sufficient for distance determination. More accurate period values can be found in the GCVS or in our data bank on the INTERNET at:

<ftp.sai.msu.su/pub/groups/cluster/cephheids/>

The fourth column gives the heliocentric distance, r_{hel} . The fifth column indicates how the intensity-mean $\langle K \rangle$ magnitude was derived. k means that it is known directly from observations; bv , rc , ic , and i , that it was inferred from observed $\langle B \rangle$ and $\langle V \rangle$, V and R_C , V and I_C , V and I , respectively. The subsequent columns give light-curve parameters – amplitude, Amp , magnitude at maximum light, MAX, and intensity-mean magnitude, $\langle m \rangle$, for each of the filters B , V , R , I of the Johnson system and filters R_C and I_C of the Cron–Cousins system.

4. Conclusion

Our analysis of all available photoelectric photometry of Galactic Cepheids in filters B , V , R , and I of Johnson's wide-band system and filters R_C and I_C of the Cron–Cousins system yielded reliable and accurate light curves (at least in two filters) for 455 classical Cepheids. For

these stars we derived accurate light-curve parameters (amplitudes, magnitudes at maximum light, and intensity means) and distances. The resulting catalogue will be used to analyse the properties and space distribution of Cepheids and to investigate the structure and kinematics of the Galactic disk. The data can also be used to test theories of stellar pulsation and late stages of stellar evolution.

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