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Photometry of eclipsing binary stars in the Large and Small Magellanic Clouds

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Abstract. CCD uV_JI_C photometry was obtained for three eclipsing binaries in the Magellanic Clouds and the preliminary analyses of their light curves has been made using a modified Wilson code. The LMC system, MACHO*05:36:48.7−69:17:00, is detached and eccentric, most likely comprising of two similar stars. The system has apsidal motion with a period of 100 ± 5 years. Initial results for two other systems in the SMC, MOA J005018.4−723855 and MOA J005623.5−722123, indicate circular orbits with the former semi-detached and the latter detached with two stars of very similar temperature.

1. Introduction

Eclipsing binaries are a source of fundamental stellar parameters and can be used as stellar standard candles for extra-galactic distance determination. The distance to the LMC is still a topic of contention. To determine the fundamental stellar parameters and distance, data sets from photometric, spectroscopic and ideally spectrophotometric observations are required with high accuracy.

2. Observations

Photometric time series observations of three targets, one in the LMC (Alcock 1997) MACHO*05:36:48.7−69:17:00, two in the SMC (Bayne 2002), MOA J005018.4−723855 and MOA J005623.5−722123, were made using the 1-m telescope at the Mount John University Observatory (MJUO). The southern latitude of MJUO allows photometric observations of the Magellanic Clouds throughout the year. Observations were made using a SITe 003AB 1024×1024 pixel CCD array with $24\,\mu$m pixel size. The observations were in three bandpasses: Strömgren u, Johnson V_J and Cousins I_C. The observations spanned 1268, 618 and 682 d respectively.

3. Data reduction

The targets are located in reasonably crowded fields, therefore image subtraction techniques were employed rather than traditional profile fitting techniques such as DAOPHOT II, for the initial reduction. The program used was ISIS-2.1 (Alard

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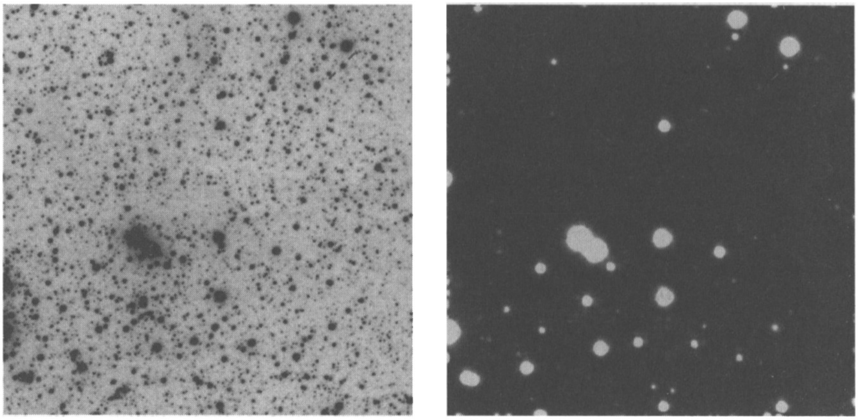

Figure 1. The reference frame for MACHO*05:36:48.7−69:17:00, I_C bandpass (left) and the frame containing the variable stars in the reference frame (right). The target is indicated. The variable stars are depicted as white circular objects, the larger star-like white objects are stars which are saturated on the reference frame.

2000a, Alard & Lupton 2000). Flux differences were used, i.e. an a.c. signal rather than a d.c. flux signal (Woźnaik 2002) in absolute or relative measures (magnitudes). The reference frame for each target and bandpass was selected. This was invariably the best seeing frame. In cases where more than one image was considered acceptable for the reference, the images were stacked. This improved the signal-to-noise of the reference frame. In order to obtain an estimate of the magnitude, DAOPHOT II was applied to the reference frame to extract the background from the target star. A frame containing the background and saturated stars was subtracted from the same frame, but with the addition of the target star. This, therefore, left only the target star, with the background level at zero. This was passed to ISIS-2.1 to obtain the flux using the same settings as used in the images-subtraction process (see Fig. 1).

4. Light curve analysis

The analysis of the photometric light curves was performed using a modified version of the Wilson code (Wilson 1994). This version incorporated an atmosphere routine using Kurucz model atmospheres with the adopted abundances for the LMC and SMC of m/H = −0.3 and −0.5 respectively. The apparent magnitudes of the targets in both the Clouds indicate they are early B stars, therefore gravity darkening would be expected. Additionally, the light curve parameters for the primary at fixed temperatures were calculated over the range 20 000 K to 35 000 K, with the secondary allowed to vary. The inclination and potentials, Ω_1 and Ω_2, were also allowed to vary. The axial rotation rate was set equal to the orbital values with the expectation of the eccentric system, whose value was synchronized to the value at periastron. Here we present preliminary results of *WD* fits to the phased light curve for the three systems (Fig. 2).

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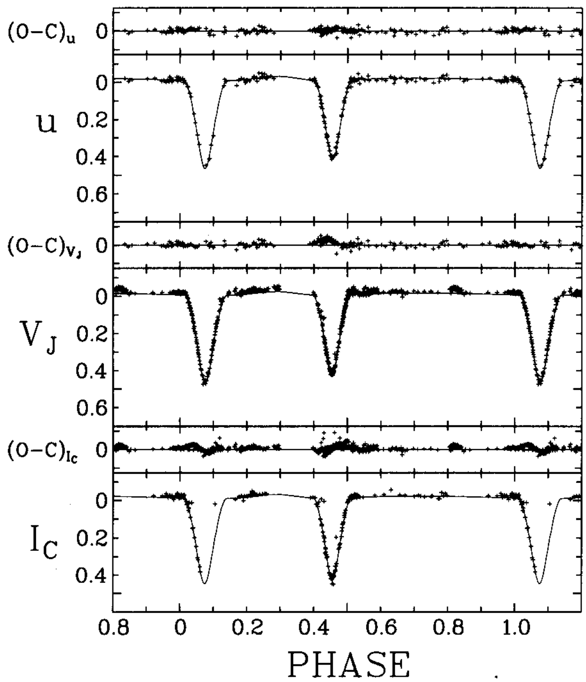

Figure 2. A Wilson code fit for MACHO*05:36:48.7−69:17:00. The normalized photometric data are plotted (Variable minus Comparison) as crosses and the light curve model as a line. The deviations of Observed−Calculated are plotted above the respective light curve. The solution present is for $T_{\mathrm{eff},1}$=27 500 K and $T_{\mathrm{eff},2}$=25 000 K. The eccentricity of the system is 0.2.

A full analysis of these systems cannot be made with photometry alone. Spectroscopy, namely radial velocities, are required to place constraints on the masses and remove any ambiguity, as well as scale the system, semi-major axis, a. Spectrophotometry is required to further constrain the reddening and temperatures, as most flux from these stars is emitted at UV wavelengths.

5. Conclusion

The analyses of the targets are providing bounds for the systems, although spectroscopic radial velocities (such as those already obtained from VLT-UVES for other Magellanic Cloud targets) are required to remove ambiguity in the radius ratio R_1/R_2, especially for MACHO*05:36:48.7−69:17:00. The apsidal period for this target was determined with the aid of the MACHO data. Both SMC targets can be used for distance determination as argued by Wyithe and Wilson (2002). The solutions for MOA J005018.4−723855 have produced a range

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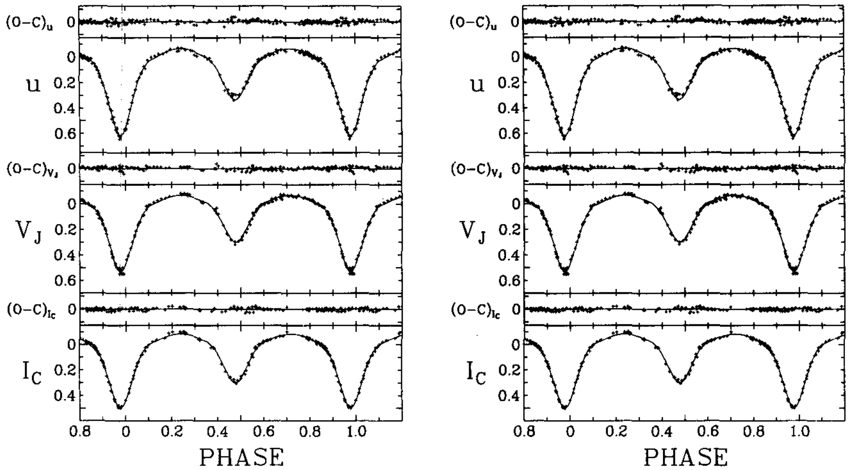

Figure 3. A Wilson code fit for MOA J005018.4−723855 (left) and MOA J005623.5−722123 (right). Blending in both of these systems, more so for MOA J0518.4−723855, required the addition of third light.

of effective temperatures for various inclinations. However the model bounds are yet to be finalized, although a primary $T_{eff,1}$=20 000 K appears reasonable given M_V=−4.1. Initial analysis of MOA J005623.5−722123 indicates two very similar components, given eclipse depths all bandpasses are similar. For all systems, solutions need to be compared to evolutionary models to obtain the more astrophysically plausible solutions.

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References

Alard C. 2000a, A&AS, 144, 363

Alard C., Lupton R.H. 2000 ApJ, 503, 325

Alcock C. et al. 1997, AJ, 114, 326

Bayne G.P. et al. 2002 MNRAS, 331, 609

Benedict G.F. et al. 2002 ApJ, 123 473

Wilson R.E. 1994 PASP, 106, 921

Woźnaik P.R. 2000 Acta Astronomica, 50, 421

Wyithe J.S.B, Wilson R.E. 2002, ApJ, 571, 293

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