Magellanic Cloud Eclipsing Binaries: Distances and Dimensions

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1 Introduction

The reasons for studying Magellanic Cloud Eclipsing Binaries (MCEBs) are well documented elsewhere, in particular see the article by Clausen in these proceedings. Let us simply reiterate the primary goals of this research, namely the determination of accurate distances and dimensions.

In section 2 we discuss the analysis of the Magellanic Cloud eclipsing binary system HV 982 based on previously unpublished radial velocity curves in conjunction with other already published light curves, Strömgren *uvby* photometry and *IUE* spectrophotometry.

Catalogues recently published by the MACHO and OGLE groups [1,6] based on multi-bandpass CCD photometry permit the selection of targets which are ideally suited for the accurate determination of component dimensions and system distances – a process that was somewhat more 'hit and miss' based on the photographic surveys of the past. These new surveys also provide somewhat fainter systems which thus have components with much smaller masses than have been studied in the Magellanic Clouds to date, an important extension to this ongoing programme. In section 3 we discuss the selection of target candidates for a new observational programme with these thoughts very much in mind.

2 Harvard Variable 982

The well detached, eccentric, 5.33 day period early B-type eclipsing binary HV 982 in the LMC is an exciting prospect. High quality CCD light curves with excellent coverage in u, V and I_{C} (as well as sparser coverage in vby) have been obtained with the McLellan 1-m telescope at the Mount John University Observatory in New Zealand [5]. Radial velocity curves have been made by Niemela with the 2.15-m telescope at CASLEO, San Juan, Argentina. These previously unpublished radial velocities are tabulated in table 1. Additional photometric and spectrophotometric data including Strömgren *uvby*

CCD light curves and calibrated photometry obtained at the Danish 1.54-m telescope at ESO, La Silla and *IUE*–SWP and more recently *HST*–FOS uv-spectrophotometry have been obtained, and are under analysis.

Table 1. Radial velocity measurements for HV 982. For each velocity measurement the number of lines the measurement is based (n) on and the mean error (m.e.) are also given. The Remarks indicate the nature of the lines in the spectra used for determination of the radial velocities. Spectra where lines are clearly seen to be double are included with weight 1.0 in the analysis, while measurements based on poorly resolved lines ('double?') are included with weight 0.5. Spectra where only single lines are evident are excluded from the analysis.

	Component A			Component B			
HJD -2450000.0	V_A km/s	n_A	$m.e._A$ km/s	V_B km/s	n_B	$m.e._B$ km/s	Remarks
432.783	+457	6	28	+117	6	29	double?
433.777				+242	9	11	single lines
434.726				+322	7	6	single lines
435.718	+45	6	8	+431	8	13	double lines
435.810	+57	4	10	+475	5	18	double lines
436.740	+284	8	13				single lines
437.718	+354	3	28	+112	3	33	double?
806.118	+424	9	29	+94	9	17	double?
807.656				+252	11	6	single lines
808.753	+135	6	26	+490	5	35	double lines
809.688	+62	5	19	+430	5	16	double lines
810.692	+280	7	8				single lines
811.730	+473	8	18	+66	7	16	double?
812.707	+243	7	10				single lines
862.538	+64	4	14	+449	5	17	double lines

Analysis of the radial-velocity curves yield a mass ratio close to unity but the uncertainty is of the order of 0.1. This uncertainty in the mass ratio leads to correspondingly large uncertainties in the remaining directly related parameters of the system, in particular the derived masses and radii are $14\pm2\,M_\odot$ and $8.0\pm0.5\,R_\odot$ respectively. A preliminary estimate of the $T_{\rm eff}$s for the components (the individual $T_{\rm eff}$s differ by only a few percent) based on the Danish-1.54m Strömgren photometry is $24\,000\pm1000$ K and this implies $(m-M)_0 = 18.7\pm0.15$ [Clausen, private communication]. It is known that radial velocities based on lower resolution spectra and poorly resolved lines tend to underestimate the physical size of eclipsing binaries [2]. If this applies in this case we might expect HV 982 to be even more massive and consequently even further away in contrast to other recent results indicating the LMC is possibly rather closer, e.g. [4] and references therein. Higher accuracy radial-velocity curves are fundamental to resolving this problem. VLT + UVES will be an ideal instrument for obtaining the required observations for this system (and many others). Exposures of approximately one hour should yield high resolution ($R = 55\,000$), high signal to noise ($S/N = 100$) spectra, according to the exposure calculator. The all but complete data set for HV 982 thus makes it a potentially very fruitful object for study with the VLT in the future.

3 Moving down the HR diagram

The faintest eclipsing systems listed in the Harvard College Observatory catalogues of variable stars in the Magellanic Clouds [3] are no fainter than about $m_{\mathrm{PG}}{\sim}16.8\,\mathrm{mag}$. The recently published catalogues by the MACHO group for the LMC [1] and by the OGLE group for the SMC [6] provide systems at least 2 magnitudes fainter. Furthermore the Harvard catalogues lists only 108 systems in total in the two galaxies, whereas the MACHO catalogue lists 611 systems and the OGLE catalogue lists 1459 systems. The new catalogue also provide many more well detached systems in comparison to the Harvard catalogues, simply due to observational bias – non well detached systems are continually varying and thus much easier to detect than the relatively short periods of variability of well detached systems. This is an important development since well detached systems are much better suited to the purposes of the studies discussed here providing the most accurate source of fundamental data relevant to 'normal' single stars.

Because of these limitations of the Harvard catalogues, which until the publication of the new microlensing project catalogues were the only useful source of potential targets, studies of well detached systems have been limited to a rather confined region of the Hertzsprung-Russell (HR) Diagram namely B0 to B1.5 or perhaps B2.

The new catalogues however provide potentially excellent targets whose components should be as late as A0. A new initiative has therefore been undertaken to observe (initially) twelve new systems in each of the Magellanic Clouds in the range B2–A0. The chosen systems are shown in the HR diagrams in figure 1. The systems were chosen on the basis of their magnitudes and colours, the shape of their light curves and the crowdedness of their immediate surroundings.

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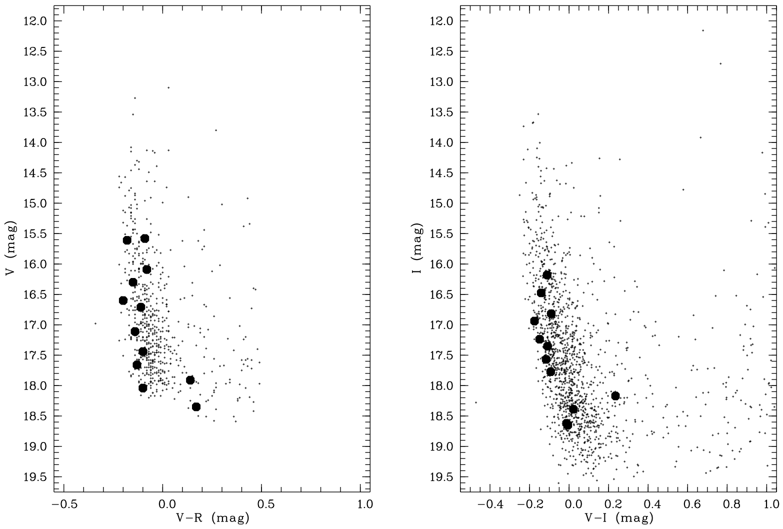

Fig. 1. HR diagrams for the LMC and SMC. The data are taken from the MACHO (LMC) and OGLE (SMC) catalogues of eclipsing binaries. The small crosses show all the systems from the respective catalogues while the large filled circles show the twelve systems in each galaxy chosen for a new project to investigate Magellanic Cloud stars in the spectral range B2–A0.

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