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Ground-Based *BVRI* Time-Series Follow-Up Observations for the RR Lyrae stars in *Kepler* Field

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Abstract. Time series observations for the 41 RR Lyrae stars in *Kepler*'s fields were carried out in 2010 to 2013 using a number of meter class (or smaller) telescopes. These telescopes include the 1-m and 41-cm telescopes of Lulin Observatory (LOT and SLT respectively, Taiwan), the 81-cm telescope of Tenagra-II Observatory (TNG, Arizona, USA), the 1-m telescope at the Mt. Lemmon Optical Astronomy Observatory (LOAO, Arizona, USA), the 1.8-m and 15-cm telescopes at the Bohyunsan Optical Astronomy Observatory (BOAO, Korea), and the 61-cm telescope at the Sobaeksan Optical Astronomy Observatory (SOAO, Korea). All of these telescopes were equipped with commercial available CCD imagers, and the observations were done in standard *BVRI* filters. Photometric calibration of the RR Lyrae light curves was done with standard stars listed in Landolt standard stars [1]. Observations of selected Landolt standard stars (centered on SA 107-456 & SA 110-232) in Johnson-Kron-Cousins *BVRI* filters, spanning three distinct airmasses, were done with the 81-cm Tenagra II telescope on 25 June 2011. Raw imaging data were reduced with IRAF in the same manner as in the case of the RR Lyrae, and astrometric calibrated with astrometry.net [2]. We calibrated *BVRI* magnitudes for 40 RR Lyrae stars.

1 Photometric Calibration and Results

Photometric calibration of the RR Lyrae light curves was done with standard stars listed in [1] (hereafter Landolt standard stars). Observations of selected Landolt standard stars (centered on SA 107-456 & SA 110-232) in Johnson-Kron-Cousins *BVRI* filters, spanning three distinct airmasses, were done with the 81-cm Tenagra II telescope on 25 June 2011. Raw imaging data were reduced with `IRAF` in the same manner as in the case of the RR Lyrae, and astrometric calibrated with `astrometry.net` [2]. Aperture photometry of the Landolt standard stars were obtained using an aperture of 7-arcsecond radius. These instrumental magnitudes (normalized with exposure time) were then used to solve for the following two sets of transformation equations:

$$b = B + ZP_B + \kappa_B X_B + C_B(B - V), \quad v = V + ZP_V + \kappa_V X_V + C_V(B - V), \tag{1}$$

$$r = R + ZP_R + \kappa_R X_R + C_R(R - I), \quad i = I + ZP_I + \kappa_I X_I + C_I(R - I), \tag{2}$$

where the lower case letters (b, v, r & i) represent the instrumental magnitudes, the upper case letters (B, V, R & I) are standard magnitudes adopted from [1], and X is the airmass. Coefficients that need to be solved are ZP, κ and C: represent the zero-point, extinction-coefficient and color-coefficient in a given filter, respectively. The solutions of these coefficients are summarized in Table 1.

Derived V magnitude and colors for 40 RR Lyrae stars are presented in Table 2.

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Table 1. Solutions of the transformation equations.

Band	ZP	κ	C	σ
B	2.993 ± 0.084	0.520 ± 0.061	−0.079 ± 0.022	0.031
V	2.787 ± 0.055	0.325 ± 0.040	0.052 ± 0.014	0.019
R	2.488 ± 0.103	0.233 ± 0.060	0.431 ± 0.118	0.023
I	3.653 ± 0.104	0.153 ± 0.059	0.053 ± 0.120	0.023

Table 2. Derived V magnitude and colors.

KIC	V	$(B-V)$	$(V-R)$	$(V-I)$	KIC	V	$(B-V)$	$(V-R)$	$(V-I)$
3733346	12.822	0.416	0.323	0.676	7742534	16.594	0.388	0.263	0.490
3864443	15.790	0.492	0.523	0.784	7988343	14.879	0.800	0.458	0.982
3866709	16.717	0.482	0.325	0.677	8344381	17.043	0.280	0.260	0.621
4064484	14.635	0.345	0.253	0.569	8832417	13.195	0.429	0.300	0.648
4484128	15.614	0.506	0.368	0.799	9001926	17.309	0.392	0.320	0.584
5299596	15.677	0.723	0.523	1.055	9453114	13.513	0.208	0.172	0.491
5520878	14.245	0.295	0.223	0.490	9508655	15.966	0.357	0.271	0.592
5559631	15.045	0.672	0.466	0.933	9578833	16.743	0.383	0.282	0.588
6070714	16.016	0.748	0.502	1.002	9591503	13.330	0.366	0.263	0.623
6100702	13.802	0.520	0.323	0.689	9658012	16.067	0.433	0.335	0.706
6183128	16.422	0.413	0.309	0.651	9697825	16.278	0.366	0.293	0.631
6186029	17.519	0.395	0.307	0.638	9717032	17.178	0.424	0.292	0.701
6763132	13.538	0.338	0.275	0.618	9947026	13.583	0.446	0.288	0.621
6936115	12.959	0.342	0.280	0.628	9973633	17.731	0.604	0.499	1.004
7021124	15.879	0.405	0.345	0.691	10136240	16.223	0.420	0.267	0.593
7030715	13.392	0.392	0.338	0.712	10136603	14.668	0.401	0.290	0.603
7176080	17.372	0.360	0.279	0.615	10789273	14.252	0.382	0.258	0.539
7257008	16.674	0.312	0.233	0.572	11125706	11.920	0.425	0.276	0.590
7505345	14.434	0.355	0.278	0.541	11802860	12.892	0.421	0.264	0.522
7671081	16.997	0.349	0.292	0.633	12155928	14.853	0.290	0.264	0.540

References

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