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Assessing the photometric calibration of the ASAS survey

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Abstract. We compare bona fide calibrated mean VI_C magnitudes of several hundred stars found in the CCD frames taken in 2012 during our photometric observations of 109 Cepheids and RR Lyrae type stars made at the South African Astronomical Observatory to the corresponding mean VI_C magnitudes measured in the course of the ASAS survey to assess the quality of ASAS photometry and derive the appropriate transformation equations. We conclude that as far as the only serious caveat due to photometric errors, which range from $\sim 0.05^m$ for relatively bright stars to about $\sim 0.15^m$ for $\sim 14^m$ stars and translates into extra fractional distance error of 0.025 – 0.07

1. Introduction

The ultimate goal of the ASAS project (Pojmanski 1997, 2002) initiated in 1996 by Prof. Bohdan Paczynski was to detect and investigate variable stars over the entire part of available sky. The complete coverage of the Southern sky (south of declination $\delta = 28^o$) and rapidly increasing coverage of the Northern sky combined with a coverage rate of about once in 1 to 3 days makes this project extremely valuable source of information about variable stars. However, the large pixel size ($\sim$ 14 arcsec) combined with the monochromatic nature of photometric reduction may be a potential caveat resulting in unaccounted color terms in ASAS photometry. Here we try to assess the photometric quality of V-band ASAS photometry using our VI_C CCD photometry of ASAS stars found in the frames taken during our observations of Cepheids and RR Lyrae variables.

2. The data and reduction

Our working sample consists of 459 stars with > 20 ASAS V-band measurements found in the CCD frames taken in the process of our observations of 109 Cepheids and RR Lyrae variables made in 2012 at the South African Astronomical Observatory.

We first reduced the observations made during photometric nights. We used for each photometric night the method of Young & Irvine (1967) to determine atmospheric extinction at two-to-three hour intervals by observing two pairs of extinction stars (a red and a blue one) in succession: one pair was located near zenith, and another, near airmass $\sim$2. We further determined the extra-atmospheric magnitudes of extinction stars selected from E regions(Menzies et al. 1989) and used these magnitudes to measure extinction based on observations of one of the two star pairs near the center of the two-to-three hour interval mentioned above.

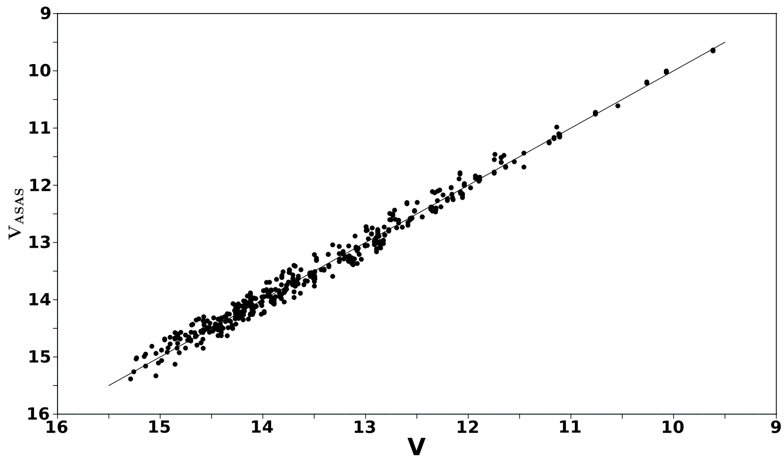

Figure 1. ASAS V-band magnitudes vs. our photometry.

We then used the same measurements of the above standards to compute the transformation coefficients ζ and μ from extra-atmospheric magnitudes b, v, and i into magnitudes of the BVI_c system of Cousins (1976):

$$\begin{aligned} B &= b + \zeta_B\,(B - V) + \mu_B \\ V &= v + \zeta_{BV}\,(B - V) + \mu_{BV}1 \\ V &= v + \zeta_{VI}\,(V - I)_c + \mu_{VI} \\ I_c &= i + \zeta_I\,(V - I)_c + \mu_I \end{aligned} \quad (1)$$

$$(2)$$

and iteratively transformed instrumental magnitudes into the standard system setting the colour indices $B - V$ and $V - I_c$ equal to zero at the first iteration.

3. Transformation

Figure 1 shows the average V-band ASAS magnitudes of 459 stars plotted as a function of the corresponding calibrated V-band magnitudes based on our CCD observations. The simple transformation equation (without color terms) has the form:

$$V_{ASAS} - 13 = -0.011(\pm 0.007) + 0.990(\pm 0.005) \cdot (V - 13) \pm 0.13 \quad (3)$$

Or, given that the coefficient at V differs marginally from unity:

$$V_{ASAS} - V = -0.014(\pm 0.006) \pm 0.13 \quad (4)$$

The equation with a $(B - V)$ color term has the form:

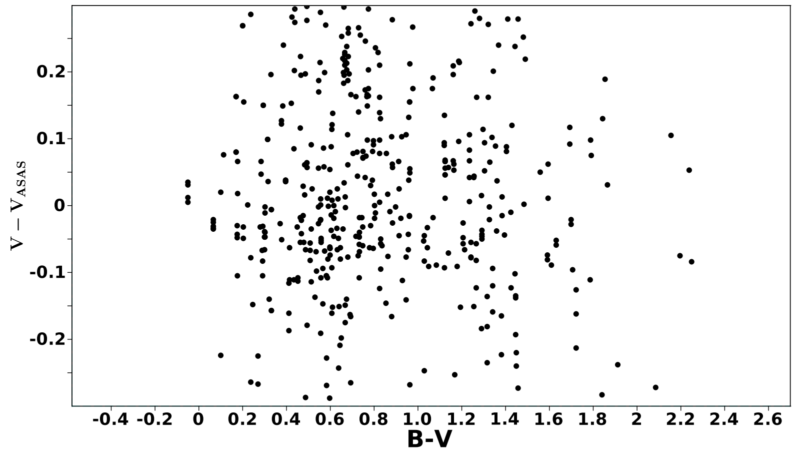

Figure 2. ASAS V-band minus our V-band magnitude difference as a function of $B-V$ color.

$$V_{ASAS} - V = -0.013(\pm 0.006) - 0.004(\pm 0.002) \cdot (B - V) \pm 0.13 \quad (5)$$

And that with a a $(V - I_C)$ color term:

$$V_{ASAS} - V = -0.024(\pm 0.007) - 0.009(\pm 0.004) \cdot (V - I_C) \pm 0.13 \quad (6)$$

The color terms can be seen to be practically insignificant in both cases as can be seen from Figs. 2 and 3.

4. Conclusions

Thus the results of a comparison of calibrated BVI_C photometry obtained as a by product of our CCD observations of Cepheids and RR Lyrae type variables with ASAS V-band photometry of the same stars further corroborates the unquestionably high quality of the latter despite the monochromatic nature of photometric reduction adopted in the ASAS project. We find the color terms to be of no particular significance. Given that the coefficients at the (B_V) and $(V-I_C)$ colors are equal to 0.004 and 0.009, respectively, even very coarse color estimates (e.g., based on USNO-B1.0 photographic data(Monet et al. 2003)) are sufficient to account for color terms with an accuracy better than 0.01^m. Hence the ASAS V-band photometry can be used to derive bona fide light-curve parameters for variable stars — first and foremost such fundamental distance indicators and kinematic tracers like, e.g., Cepheids, RR Lyrae type stars with the only limitation being the limited photometric accuracy — from $\sim 0.05^m$ for bright stars to about $\sim 0.15^m$ for $\sim 14^m$ stars — which translates into extra fractional distance error of $0.025 - -0.07$.

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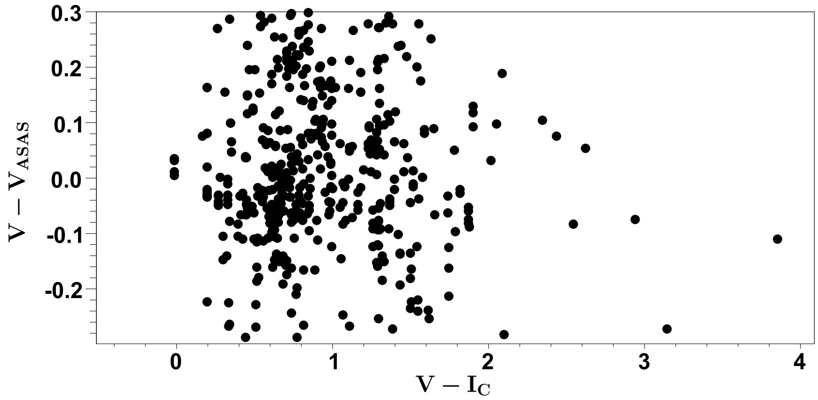

Figure 3. ASAS *V*-band minus our *V*-band magnitude difference as a function of $V - I_C$ color.

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