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Advantages and drawbacks of the ISM method in globular cluster photometry

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Abstract. In the frame of our survey on the variable stars in galactic globular clusters, we tested the promising new photometric technique the: Image Substraction Method (Alard & Lupton 1998, Alard 2000). We found that the standard deviations of light curves are much better comparing to more common PSF methods (e.g. DAOPHOT), principally in the most crowded regions. Moreover, lots of additional variable stars became measurable with this method. Unlike previousely published data we transformed our results into conventional magnitudes. The accuracies of the derived magnitudes are discussed.

All previously published data where ISM photometry was applied to globular clusters (Olech et al. 1999, Kopacki 2000), were in relative units (e.g. e^-/ADU) and this is not an accident! The big strength of ISM – that it is a relative method – is at the same time its serious drawback as well. The method serves differential fluxes of the variables relative to their fluxes in the reference frame, that is: $\Delta I_i^{(j)} = I_0^{(j)} - I_i^{(j)}$, where $I_0^{(j)}$ and $I_i^{(j)}$ are the fluxes of the jth variable in the reference image and in the ith frame, respectively. There are two possible way to convert these into the usual instrumental magnitudes.

[1] If both magnitudes ($m_0^{(j)}$) and fluxes ($I_0^{(j)}$) for each variables can be *measured* in the reference frame, we simply apply the evident formula (see also Woźniak 2000)

$$m_i^{(j)} = 2.5 \log_{10} \frac{I_0^{(j)}}{I_0^{(j)} - \Delta I_i^{(j)}} + m_0^{(j)}.$$

[2] If we know the magnitude values of two arbitrary points (e.g., $m_1^{(j)} = m_{\max}^{(j)}$, $m_2^{(j)} = m_{\min}^{(j)}$) of the light curve, and we have $\Delta I_{1,2}$ values corresponding to the same phase, we can *calculate* the values I_0 and m_0. As for each star

$$\begin{aligned} I_0 &= \frac{\Delta I_1 10^{(m_1-m_2)/2.5} - \Delta I_2}{10^{(m_1-m_2)/2.5} - 1}, \\ \text{and} \qquad m_0 &= m_k - 2.5 \log_{10} \frac{I_0}{I_0 - \Delta I_k}, \text{ where k=1 or 2.} \end{aligned}$$

These transformations give excellent result if the star is located in a relatively sparse region, where traditional PSF methods provide reference values ($m_0^{(j)}$, $I_0^{(j)}$) accurate enough. In other cases the transformed light curves are strongly distorted. To obtain reliable result the reference magnitudes have to be known with some hundredth of magnitudes.

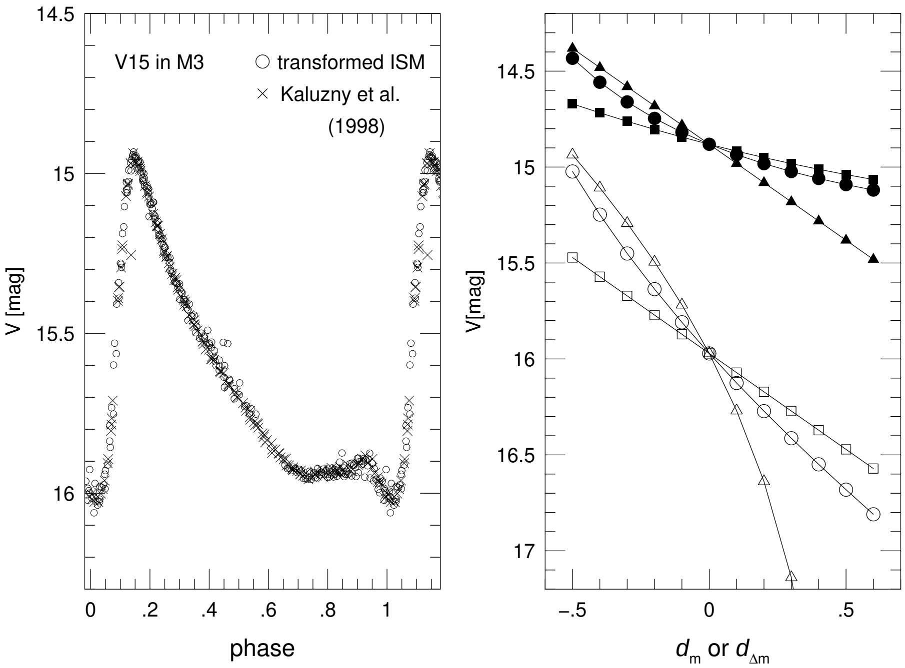

Figure 1. (left) An example for accurate magnitude transformation compared to previous DoPhot photometric results. (right) The effects of errors in magnitude zero points and amplitudes on the shape of the transformed light curve of an RR Lyrae star with $< m_{\mathrm{V}} >= 15.5$ and 1^{m} total amplitude. d_m and $d_{\Delta m}$ are the errors of the reference magnitudes and amplitude, respectively. Empty and filled simbols sign the transformed magnitudes of minima and maxima. Triangles and squeres show the effect of d_m errors in $m_0 = m_{\max}$ and $m_0 = m_{\min}$. If we know the total amplitude ($\Delta m = m_{\min} - m_{\max}$) with an error of $d_{\Delta m}$, the transformed light curve is located between the lines denoted by circles.

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