A COMPARISON OF THE PUBLISHED STELLAR
PHOTOMETRY DATA IN THE SOUTH-WEST FIELD OF
THE GALAXY M31 DISK

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Received 2006 September 22; accepted 2006 September 29

Abstract. We compare stellar photometry data in the South-West part of
the M31 disk published by Magnier et al. (1992), Mochejska et al. (2001)
and Massey et al. (2006) as the local photometric standards for the calibration
of star cluster aperture photometry. Large magnitude and color differences
between these catalogs are found. This makes one to be cautious in using these
data as the local photometric standards for new photometry.

Key words: galaxies: individual (M31) – galaxies: photometry

1. INTRODUCTION

The well calibrated local photometric standards established with small to
medium size telescopes are of great importance for accurate photometry in the
fields selected for study with the 8–10 meter class telescopes. In the course of
compact star cluster study in the South-West part of the M31 disk, Kodaira et
al. (2004) have used $B$, $V$ and $R$ photometry from Magnier et al. (1992, hereafter
Mag92) for calibration of their photometric data. We compared the Mag92 $B$
and $V$ dataset with the available stellar photometry data published by Mochejska et
al. (2001; hereafter Moc01) and found significant differences. However, the Mag92
data were used by Kodaira et al. because of availability of the $R$-band data. Re-
cently a new wide-field photometric survey of M31 was conducted by Massey et
al. (2006; hereafter Mas06). The authors described their calibration procedures
in detail and compared their own photometry with Mag92 and Moc01 datasets
giving a hint of rather large discrepancies.

Narbutis et al. (2006) used publicly available\textsuperscript{1} mosaic images of the M31
galaxy from the Local Group Galaxies Survey project performed by Mas06 to
measure compact star clusters in the $UBVRI$ passbands. For calibration of the
cluster photometry we have applied photometry datasets of Mag92, Moc01 and
Mas06. However, the systematic differences of colors and magnitude zero-points,
found by Mas06 stimulated our efforts to study this problem in more detail.

\textsuperscript{1}http://www.lowell.edu/users/massey/lgsurvey.html
Fig. 1. South-West area of the M 31 galaxy disk (DSS $B$-band image) with indicated fields under consideration. “Subaru” marks the field studied by Kodaira et al. (2004) and Narbutis et al. (2006).

2. DATA

The area selected from Mag92 for our investigation is bounded by the following J2000.0 coordinates: right ascension from $0^h 39^m 57.5^s$ to $0^h 42^m 26.5^s$ and declination from $40^\circ 32' 24''$ to $41^\circ 04' 12''$ ($\sim 28' \times 32'$), covering parts of the fields F7 and F8 from Mas06, the area studied in Kodaira et al. (2004) and Narbutis et al. (2006) and the field F from Moc01 (see Figure 1 for area limits).

The Mag92 and Moc01 photometry data were taken from the VizieR$^2$ catalog service (Ochsenbein, Bauer & Marcout 2000). The Mas06 catalog was taken from their Table 4 (online version) published at the AJ Web site.

The typical seeing (full width at half maximum of stellar images, FWHM) of the published photometric data are as follows:

\[^2\text{http://vizier.u-strasbg.fr/}\]
A comparison of the published photometry in M 31

Mag92 – 2.3″ (from 1.4″ to 4.0″);
Moc01 – 1.0″ in V-band, 1.1″ in I-band and 1.7″ in B-band;
Mas06 – 1.0″ (from 0.8″ to 1.4″).

The selection criteria of stellar objects from the compared catalogs were as follows:

Mag92 – photometric error <0.06 mag in V band and <0.08 mag in B and I bands, at least two observations in each passband available and the object is classified as a star;
Moc01 – photometric error <0.05 mag in each passband and variability index $J_S < 1.5$ (Stetson 1996);
Mas06 – photometric error <0.015 mag, at least four observations in each passband available and faint magnitude limit $V = 19.5$ mag.

Systematic object coordinate differences of Mag92, Moc01 and Mas06 data sets exceeding 1″ were found by examining regions, over-plotted on the F7 field mosaic image from Mas06. IRAF’s (Tody 1993) geoxytran procedure was used for nonlinear transformation of the object coordinates given by Mag92 and Moc01 to the Mas06 field’s F7 V-band mosaic image coordinate system. Finally, we achieved well matching (<0.2″) homogeneous coordinate systems of all three datasets and cross-identified the stars. Maximum object coordinate deviations of 0.5″ and 0.7″ were allowed for Moc01 and Mag92 star identification with the Mas06 dataset, respectively.

The selection criteria and star coordinate matching limits applied predetermined the final data sets used for further photometry comparison consisting of: 343 and 336 stars from Mag92 possessing $B-V$ and $V-I$ colors, respectively (Figure 2), and 233 and 213 stars from Moc01 possessing $B-V$ and $V-I$ colors, respectively (Figure 3). In the next section we show and briefly discuss the $B-$, $V-$, and $I-$magnitude and color differences (Mag92 and Moc01 minus Mas06) vs. corresponding magnitudes and colors from Mas06.

3. RESULTS AND DISCUSSION

Initially we tested the coordinate dependence of magnitude and color differences of datasets Mag92 and Moc01 vs. Mas06. The Moc01 photometric data obtained with a single CCD and covering a rather small field of 11′×11′ show no systematic differences larger than 0.05 mag. The Mag92 data were obtained with a CCD of a small size field-of-view (6.5′×5.7′), and our comparison area (see Figure 1) contains ~20 different Mag92 fields. However, we notice only one break in $V-I$ color differences and it is less than 0.1 mag. Relatively small coordinate dependencies of magnitude and color differences do not alter significantly the results presented in Figures 2–7.

As it can be easily seen in Figures 2 and 3, V-magnitude data are well calibrated and show no significant zero-point deviations. However, large systematic discrepancies of the Mag92 and Moc01 zero-points in respect to Mas06 are obvious for $B$ and $I$ magnitudes. This effect, most probably, occurs because of $B-V$ and $V-I$ color reduction inaccuracy due to considerable color equations of the instrumental systems and narrow color range of the standard stars used.

The differences of magnitudes and colors of the Mas06 and Mag92 from one side and of Moc01 from the other side (plotted vs. $B-V$) are shown in Figures 4 and 5. Corresponding plots vs. $V-I$ are shown in Figures 6 and 7. These plots
Fig. 2. Differences of $B$, $V$ and $I$ magnitudes from Mag92 and Mas06 plotted vs. corresponding magnitudes from Mas06.
Fig. 3. Differences of $B$, $V$ and $I$ magnitudes from Moc01 and Mas06 plotted vs. corresponding magnitudes from Mas06.
Fig. 4. Differences of $B$ and $V$ magnitudes and $B-V$ colors from Mag92 and Mas06 plotted vs. $B-V$ from Mas06.
Fig. 5. Differences of $B$ and $V$ magnitudes and $B-V$ colors from Moc01 and Mas06 plotted vs. $B-V$ from Mas06.
Fig. 6. Differences of $V$ and $I$ magnitudes and $V-I$ colors from Mag92 and Mas06 plotted vs. $V-I$ from Mas06.
Fig. 7. Differences of $V$ and $I$ magnitudes and $V$–$I$ colors from Moc01 and Mas06 plotted vs. $V$–$I$ from Mas06.
confirm the above-stated presumption about color equation determination difficulties and strongly imply that even carefully calibrated CCD photometry cannot guarantee reliable photometric data suitable, e.g., for star formation history analysis even in such a well-studied galaxy as M31.

Kaluzny et al. (1998) discussed the discrepancy and nonlinearity of their $V-I$ colors in respect to Mag92 data. We show that this discrepancy is easily seen in Figure 6 as well, where Mag92 and Mas06 photometric data are compared. However, $V-I$ colors of Moc01 also show large systematic deviations from Mas06. In both cases, huge color deviations, as large as $\sim 0.3$ mag, can hardly be accounted for color equation, crowding and seeing or non-photometric weather effects.

Solely on the ground of Figures 2–7 it is rather difficult to decide which of these three datasets is the most reliable. The careful reduction and calibration method used by Mas06, as well as internal consistency check of overlapping fields, makes us believe that this is the most accurately calibrated photometry dataset in the M31 galaxy to date.

The surprisingly large magnitude and color differences between the carefully calibrated Mas06, Mag92 and Moc01 catalogs, found in this paper, suggest that users should be cautious using the published photometric data as local photometric standards for calibration of the new photometry.

ACKNOWLEDGMENTS. This work was financially supported in part by a Grant T-08/06 of the Lithuanian State Science and Studies Foundation. This research has made use of the SAOImage DS9 developed by Smithsonian Astrophysical Observatory, and the Digitized Sky Surveys produced at the Space Telescope Science Institute under U.S. Government grant NAG W-2166.

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