The Cepheid Distance to NGC 0247

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ABSTRACT

We report VRI CCD observations of nine Cepheids in the South Polar (Sculptor) Group spiral galaxy NGC 0247. Periods of these Cepheids range from 20 to 70 days. Over the past 20 years the very brightest Cepheid in our sample, NGC 0247:[MF09] C1, has decreased its period by 6%, faded by 0.8 mag in the V band, and become bluer by 0.23 mag in (V-I). A multi-wavelength analysis of the Cepheid data yields a true distance modulus of \( \mu_o = 27.81 \pm 0.10 \) mag (3.36\( \pm \)0.16 Mpc) with a total line-of-sight reddening of \( E(V-I) = 0.07 \pm 0.04 \) mag, after adopting an LMC true distance modulus of 18.5 mag and reddening of \( E(B-V) = 0.10 \) mag. These results are in excellent agreement with other very recently published (Cepheid and TRGB) distances to NGC 0247. Combining both Cepheid datasets gives \( \mu_o = 27.85 \pm 0.09 \) mag (3.72\( \pm \)0.15 Mpc) with \( E(V-I) = 0.11 \pm 0.03 \) mag.
Subject headings: Cepheids: galaxies: distances and redshifts — galaxies: individual (NGC 0247) — galaxies: Sculptor Group

1. Introduction

In 1983 we began a ground-based project to provide a more secure calibration of the zero-point for secondary distance indicators (such as the Tully-Fisher relation) by building up a database of accurate Cepheid distances to nearby spiral galaxies. In due course the Hubble Space Telescope was launched and other activities took precedence over the ground-based effort. Preliminary mention of work on Cepheids discovered in NGC 0247 was given in Freedman et al. (1988) and again in Catanzarite, Freedman, Horowitz & Madore (1994) but details were never published, until now. Here we present the photometric data and provide a brief analysis leading to a distance determination to NGC 0247 based on nine Cepheids discovered in NGC 0247 some twenty-five years ago. We then go on to compare it with new observations published by Garcia-Varela et al. (2008, hereafter [GV08]).

2. Observations

Observations for this program were carried out over a span of eight years (giving a time baseline of almost 3,000 days). Observing began first at the Cerro Tololo 4m, and was completed using the 2.5m duPont telescope at Las Campana, Chile. Three fields of NGC 0247 were surveyed in $B$, $V$, $R$, and $I$ filters at the Cerro Tololo 4m telescope during November 1984 to November 1988. Figure 1 shows a photograph of NGC 0247 with the three fields delineated. The coordinates of the CCD field centers are given in Table 1. From the second through the fourth year of the program data were obtained in the service-observing mode offered at CTIO; those data were taken by M. Navarrete. For most of the runs the $512 \times 320$ RCA chip #5 (having a scale of $0.60$ arcsec/pxl and a total field of view of $3'$ by $5'$ at the prime focus) was used. In 1988 a different RCA chip (#4) with similar characteristics was substituted. Exposure times for these frames were typically 400 sec in $B$ and 300 sec in $V$, $R$ and $I$. The frames were bias-subtracted, flat-fielded, and defringed using standard data-reduction packages available at Cerro Tololo. Beginning in 1990, the observing program for the Sculptor galaxies shifted to the duPont 2.5m telescope at the Las Campanas Observatory. $BVRI$ CCD observations covering the same three selected fields were obtained in December 1990, in September 1991, and in October, November, and December 1992. Exposure times at this telescope were generally 900 sec in $B$ and 600 sec in $V$, $R$ and $I$. Most of these observations were electronically binned $(2 \times 2)$ at the
telescope. For the 1990 and 1991 runs, the FORD1 CCD chip was used. For the October and November 1992 runs a Tektronix CCD chip (TEK4) was used; for the December 1992 runs, Tektronix CCD chips were also used (TEK3 and TEK4). These chips each had dimensions of 2048 × 2048 pixels; the image scales obtained were: FORD1: 0.16 arcsec/pxl; TEK3: 0.23 arcsec/pxl; and TEK4: 0.26 arcsec/pxl. The survey totalled about 250 exposures on 29 different nights over a span of eight years. Table 2 gives a journal of the observations.

3. Photometry Reduction and Calibration

Photometric calibration of the CTIO frames was accomplished using E-region standards in E1, E2, E3, E7, E8, and E9 (Graham 1984) and in SA 98 (Landoldt 1983). BVRI standards were taken on 20 independent photometric nights. As described in Freedman et al. (1992), a check on the external accuracy of the photometric calibration for these runs was made by individually calibrating the frames for NGC 0300. The magnitudes for the brightest stars were in agreement to within 0.01-0.03 ± 0.03 mag of the average for all filter/field combinations.

The CCD frames from CTIO were reduced using both DoPHOT (Schechter, Mateo & Saha 1993) and DAOPHOT (Stetson 1987), and cross-checked. The unresolved background level in NGC 0247 is highly non-uniform, and is characterized both by regions in which there are strong spiral arms as well as relatively blank, interarm regions. In order to maximize the detection limits of the algorithm FIND in DAOPHOT, the frames were first median-smoothed using a 7 × 7 pixel boxcar averaging scheme, and subtracted from the original frames.

Details of the calibration process are discussed in (Freedman et al. 1992). The LCO data were reduced using a variant of the DoPHOT package (Mateo & Schechter 1989). This version of DoPHOT uses median smoothing to construct an initial model of the background sky before searching for objects. The sky model is refined after objects at the next-to-the-lowest threshold have been found and subtracted. The refined sky model is then adopted as the baseline, and objects are again found down to the lowest threshold and their PSF parameters re-measured. LCO frames were brought onto the CTIO calibrated magnitude system by the following process: The \((B − V)\) color term for the CCD chips used at LCO relative to RCA chip used in the CTIO observations was measured and a correction was applied to the LCO \(B\) photometry (the LCO \(V\) photometry had no significant \((B − V)\) color term.) Next, the magnitude zero-point of each LCO frame was offset to the instrumental zero-point of a fiducial CTIO frame, for the corresponding field and filter. The calibration transformation derived for the fiducial CTIO frame was then applied to the LCO data.
4. The Cepheids

For Fields 1 and 3 all of the observations were tied to the photometric zero point for October 7, 1988. Observations on this night were taken under excellent seeing conditions and had the best photometric calibration available to us. For Field 2, October 13, 1988 was used to calibrate the data. To put all of the stars in each field on the same coordinate system, all frames from each field were spatially registered to the October 7, 1988 V frame for that field, (since that was the best or close to best V night for all three fields). Coordinate transformations produced matches with \( \text{rms} \) scatter of \( \pm 0.30 \) pixels or better. Calibrated, matched photometry files containing the entire set of observations for each field/bandpass combination were produced. Stars with high internal V magnitude dispersion were then identified as described in Freedman et al. (1994). These variable candidates were then subjected to a further test: a star was flagged as a Cepheid candidate only if the histogram of its magnitudes was consistent with a uniform magnitude histogram, as expected for Cepheids. All three fields were searched for variables down to a signal-to-noise level of 1.5\( \sigma \). The V photometric data for each candidate was then phased to the twelve periods (in the range of 1 to 100 days) with the lowest phase dispersions, using a routine based on the Lafler-Kinman algorithm (Lafler & Kinman 1965). The V light curves were then visually inspected and the best period was selected. Calibrated B, R, and I observations were then phased to this adopted period and the multi-wavelength light curves were inspected for consistency. Candidates with strong correlation of phase and amplitude between their BVRI light curves, having well-determined periods, mean colors and well-sampled light curves characteristic of known Cepheids were then identified as Cepheids. Each of these stars was then visually inspected in the best image frame to check for nearby companions. Nine Cepheids in total made it through the selection procedure. All were found in BVRI, with the exception of NGC 0247:[MF09] C9, which was too faint to be recovered on the I frames. The positions for the nine Cepheids in our sample are given in Table 3, the first 6 of which are mapped over from [GV08], with the positions for C7, C8 and C9 being on that system but having lower precision. The individual Cepheid observations are presented in Tables 4 through 12. The light curves are shown in Figure 2. The time-averaged properties of the individual Cepheids are listed in Table 4.

4.1. Other Variable Stars Found in NGC 0247

Five variable stars which could not be classified as Cepheids were also discovered. These stars are well-isolated, their photometry is well-measured by DoPHOT, and they have extremely strong BVRI correlation. Three of them are very red, and have light curves with a
Fig. 1.— *BVRI* lightcurves for the individual Cepheids. The plotted magnitude range is 5 mag in all cases. Magnitude offsets, applied, to make the lightcurves individually more visible, are given in the vertical-axis labels. In order from top to bottom the lightcurves are *I, R, V* and *B*.
“square wave” shape. If they are eclipsing variables then we have probably been unable to determine the periods correctly. A fourth object has a light curve with the right shape to be a Cepheid, but is extremely red. The fifth may be a Cepheid with an uncharacteristic light curve. The properties of these stars are summarized in Table 13.

5. The Distance to NGC 0247

A comprehensive review of previously published distance estimates to NGC 0247 is given in [GV08]. In that paper the authors also present their new $VI$ observations of 23 Cepheids in the period range 17 to 131 days. Based on those two colors they derive a true distance modulus of $27.80 \pm 0.09$ mag (3.6 Mpc) tied to an LMC true distance modulus of 18.50 mag, as also adopted in this paper. Another important independent distance measurement to NGC 0247 worth noting here, because of its comparably high precision, is the tip of the red giant branch (TRGB) distance modulus ($\mu_o = 27.81$ mag or 3.65 Mpc) published by Karachentsev et al. (2006).

5.1. Discussion of Data

The detected Cepheids at $B$ lie closer to the photometry limits than at $V$, $R$, or $I$; furthermore deriving a stable zero-point for that bandpass was found to be problematic. As such, the $B$ data were used to confirm the periods adopted here, but because of signal-to-noise and other calibration problems we do not use the $B$-band data further in this paper. The $B$-band data are listed in this paper, but readers are strongly warned against using it for anything quantitative until a proper calibration is found. The time-averaged data for our 9 Cepheids are given in Table 14. The periods cited there were derived from these data alone, but will be updated later in the paper when we consider a merger with the [GV08] sample.

As can be seen in Figure 12, the NGC 0247 PL relations in $V$, $R$, and $I$, have smaller observed dispersions than the fiducial LMC PL relations whose 2-sigma widths are shown by the dashed lines. The small observed dispersion is presumably due to small number statistics, but it could also be signalling a slight bias in the sample. If the instability strip

\footnote{In addition, an updated, on-line compilation of distances to nearby galaxies, including NGC 0247, is available through the NASA/IPAC Extragalactic Database at the following URL: \url{http://nedwww.ipac.caltech.edu/level5/NED1D/intro.html}.}
is not being fully sampled we cannot be sure that these Cepheids properly reflect the mean. An external check with the results of [GV08] (Section 6 below) would suggest that that bias (between samples) is at or below the 0.1 mag level.

5.2. PL Relations and Apparent Distance Moduli

To determine apparent $VRI$ distance moduli, residuals about the PL relations for NGC 0247 Cepheids were minimized relative to the mean LMC PL relations given in (?), and updated to the VI calibration of Udalski (2000). For a given bandpass, the LMC PL relation was iteratively shifted relative to the NGC 0247 PL relation until the $\chi^2$ of the fit was minimized. The off-set determined in this way is then the apparent distance modulus (for that bandpass) of NGC 0247 with respect to the LMC. The results of the PL-fits are shown in Figure 3. In the absence of other physical effects, determination of the true distance modulus and reddening can obtained by fitting the apparent moduli in different filters to an interstellar extinction law (e.g., Cardelli et al. 1989) originally discussed in Freedman (1998).

In Figure 4, the apparent distance moduli at $VRI$ for the Cepheid sample in NGC 0247 are plotted with respect to inverse wavelength. The solid line gives a fit to a standard (1) Galactic extinction law flanked by one-sigma error curves (dashed lines). The $VRI$ data are very well-fitted by an extinction curve (with a small positive reddening equivalent to $E(V-I) = 0.07$ mag) having an intercept corresponding to a true distance modulus of $\mu_o = 27.81 \pm 0.10$ mag (3.65\pm0.16 Mpc). The solution using only $V$ and $I$ gives essentially the same numbers ($\mu_o = 27.79 \pm 0.13$ mag; 3.61\pm0.23 Mpc).

6. Comparison with Garcia-Varela et al. (2008)

We have made a positional cross-correlation of our Cepheids with those discovered by [GV08]. Six of our nine variables were recovered by the Araucania Project, and the correct identification of these stars across the two studies is reinforced by the independently derived

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2Here we use $A_V = 3.2 \times E(B-V)$ and $A_V = 2.45 \times E(V-I)$. [GV08] choose to use a slightly different reddening law, taken from Schlegel et al. (1998), giving $A_V = 2.50 \times E(V-I)$ which is only 2\% different from our adopted value.

3All reddenings in this paper are given in terms of $E(V-I)$. For those wishing the $E(B-V)$ equivalent the appropriate conversion factor is $E(B-V)/E(V-I) = 2.45/3.20 = 0.77$
Fig. 2.— Fits of the NGC 0247 Cepheid PL-relations in $V$, $R$, and $I$ to the LMC PL-relation. Solid lines show the least-squares fit, flanked by ±2-sigma boundaries to the instability strip as derived from LMC calibrators.
Fig. 3.— Fit of the apparent distance moduli in $V$, $R$, and $I$ to a Galactic extinction law (solid line). One-sigma errors on the fit are shown with broken lines. Plotted contours are 2, 4 and 6 sigma.
periods which agree to better than 10% in most cases. We now combine the two datasets, revise the periods when possible and update the $V$ and $I$ intensity-mean magnitudes. The results of that update are given in Table 15. The combined lightcurves are shown in Figure 5.

The updated VRI [MF09] sample alone gives $\mu_V = 27.97 \pm 0.05$ mag, $\mu_R = 27.98 \pm 0.06$ mag, $\mu_I = 27.90 \pm 0.06$ mag, $E(V-I) = 0.11 \pm 0.03$ mag resulting in $\mu_o = 27.81 \pm 0.05$ mag or 3.65\pm0.08 Mpc for the 3-band fit, and $\mu_o = 27.79 \pm 0.13$ mag (3.61\pm0.23 Mpc) with E(V-I) = 0.07\pm0.04 mag for the VI fit alone.

We consider a progressive merger of the two datasets. We first apply our standard fitting techniques to the [GV08] preferred subset of 17 Cepheids, omitting as they did, the longest and shortest-period Cepheids in their sample. We get $\mu_V = 28.21 \pm 0.05$ mag, $\mu_I = 28.05 \pm 0.06$ mag, $E(V-I) = 0.15 \pm 0.03$ mag resulting in $\mu_o = 27.82 \pm 0.08$ mag or 3.66\pm0.14 Mpc. This differs from the [GV08] solution by +0.025 mag in the true modulus.

If we now update the [GV08] sample with the revised periods and magnitudes for NGC 0247:[MF09] C2 through C6 we get $\mu_V = 28.15 \pm 0.06$ mag, $\mu_I = 28.03 \pm 0.06$ mag, $E(V-I) = 0.11 \pm 0.03$ mag resulting in $\mu_o = 27.87 \pm 0.09$ mag or 3.75\pm0.15 Mpc. Augmenting the [GV08] sample with NGC 0247:[MF09] C7 & NGC 0247:[MF09] C8, plus reintroducing NGC 0247:[MF09] C1 with its first-epoch period and magnitude, in addition to its evolved values from [GV08] as described in Section 7 (below), we get $\mu_V = 28.13 \pm 0.05$ mag, $\mu_I = 28.01 \pm 0.06$ mag, $E(V-I) = 0.11 \pm 0.03$ mag resulting in $\mu_o = 27.85 \pm 0.09$ mag or 3.72\pm0.15 Mpc. The above results are summarized in Table 16.

7. The 70-Day Cepheid NGC 0247:[MF09] C1

In an attempt to update the period and combine the photometry for the longest-period Cepheid in our sample, NGC 0247:[MF09] C1, we quickly found that the mean magnitudes and colors derived from our data did not correspond to data published for it in the [GV08] study. Figure 6 shows the differences. In that plot our data are shown as circled solid symbols, phased to our adopted period of 69.9 days. Below those light curves are the data from [GV08], shown as open circles, phased to their period of 65.862 days (with an arbitrarily added phase shift of 0.6 to align the lightcurves for ease of visual comparison). The time-averaged $V$ magnitudes differ by 0.8 mag, with the most recent epoch being fainter; while the $(V-I)$ colors differ by 0.23 mag, with the most recent data being bluer. The sense of the change eliminates a self-shrouding event as the possible cause. A remaining explanation
Fig. 4.— Combined BVRI lightcurves for the individual Cepheids in NGC 0247. The plotted magnitude range is 5 mag in all cases. Magnitude offsets, applied, to make the lightcurves individually more visible, are given in the vertical-axis labels. In order from top to bottom the lightcurves are $I$, $R$, $V$ and $B$. Solid points are from this paper; open circles are from [GV08].
is that the structure of the star itself may have systematically changed in the intervening quarter century: in the face of a rising surface temperature (indicated by the decrease in the (V-I) color) and the resulting increased surface brightness, the overall radius of this star may have decreased significantly. In the process the period dropped by 6%, from 70 to 66 days.

A simple linear decrease of the period with time ($\Delta P/P = 0.0075$ day/day) fails to phase the lightcurves over the total baseline (and, in fact, destroys coherence within the individual observing campaigns). Without undertaking more sophisticated modelling we default to the next simplest conclusion that the period change was a discontinuous event. Further monitoring of this star could be reveal interesting aspects of the structure of Cepheids in general if this behavior persists.

8. Summary and Conclusions

Nine Cepheids have been identified in the Galaxy NGC 0247. Six of these variable stars have been independently found by [GV08].

The period and magnitude-updated VRI [MF09] sample alone gives apparent moduli of $\mu_V = 27.97 \pm 0.05$ mag, $\mu_R = 27.98 \pm 0.06$ mag, $\mu_I = 27.90 \pm 0.06$ mag, and $E(V - I) = 0.11 \pm 0.03$ mag resulting in $\mu_0 = 27.81 \pm 0.05$ mag or $3.65 \pm 0.08$ Mpc for the 3-band fit. These data yield a true distance modulus of $\mu_0 = 27.70 \pm 0.11$ mag corresponding to a metric distance of $3.47 \pm 0.18$ Mpc.

Combining our observations with newly published data from [GV08] in the V & I bands, and updating the periods accordingly, results in a reddening of $E(V-I) = 0.06 \pm 0.04$ mag and a (preferred) true modulus of $\mu_0 = 27.81 \pm 0.05$ mag ($3.65 \pm 0.08$ Mpc). This is (fortuitously) identical to the TRGB distance modulus recently published by Karachentsev et al. (2006) further re-inforcing the consistency of these two distance scales, which are based on largely independent assumptions, and have very different systematics.

The 70-day Cepheid NGC 0247:[MF09] C1 deserves follow-up observations to see if the extraordinary changes in its magnitude, period and color found between these epochs (first 1984-1992 and then 2002-2005) is an on-going phenomenon.

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Fig. 5.— The V and I lightcurves for the Cepheid C1 at the two epochs surveyed by [MF09] (circled solid symbols) and [GV08] (open circles). The I-band light curves are both displaced by one magnitude upward in the figure for ease of viewing. In addition the earlier data are displaced in phase by 0.6 cycles so as to align the two datasets around maximum light. The vertical displacement of the pairs of light curves in V and in I is real, indicating that the star faded by nearly 0.8 mag between the times of the two studies.
We also thank Jose Garcia-Varela, Grzegorz Pietrzyński and Wolfgang Gieren for providing their more recently acquired Cepheid data in advance of publication. This research has made use of the NASA/IPAC Extragalactic Database (NED) which is operated by the Jet Propulsion Laboratory, Caltech, under contract with the National Aeronautics and Space Administration.
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| Field      | RA(1950.0)  | Dec(1950.0)   |
|------------|-------------|---------------|
| NGC 0247:F1 | 00\textdegree 44\textquoteleft 35.4\textquoteright | −20°55'55''    |
| NGC 0247:F2 | 00\textdegree 44\textquoteleft 40.9\textquoteright | −21°04'15''    |
| NGC 0247:F3 | 00\textdegree 44\textquoteleft 33.4\textquoteright | −20°53'11''    |
| Date(UT)      | Telescope | Chip | Scale         | Fields | Filters          |
|--------------|-----------|------|---------------|--------|------------------|
| Nov. 24, 1984| CTIO      | RCA  | 0.60 arcsec/pxl | 1      | R                |
| Sept. 19, 1985| CTIO    | RCA  | 0.60 arcsec/pxl | 1      | VRI              |
| Sept. 20, 1985| CTIO    | RCA  | 0.60 arcsec/pxl | 1,2    | VR; VR           |
| Sept. 21, 1985| CTIO    | RCA  | 0.60 arcsec/pxl | 2      | BVI              |
| Sept. 22, 1985| CTIO    | RCA  | 0.60 arcsec/pxl | 1,2    | V; V             |
| Sept. 23, 1985| CTIO    | RCA  | 0.60 arcsec/pxl | 1,2    | V; V             |
| Dec. 06, 1985 | CTIO   | RCA  | 0.60 arcsec/pxl | 1      | VR               |
| Dec. 07, 1985 | CTIO   | RCA  | 0.60 arcsec/pxl | 1,2    | BVI; BVI         |
| Dec. 08, 1985 | CTIO   | RCA  | 0.60 arcsec/pxl | 1,2    | VR; VR           |
| Oct. 25, 1986 | CTIO   | RCA  | 0.60 arcsec/pxl | 1,2    | BV; RI           |
| Oct. 26, 1986 | CTIO   | RCA  | 0.60 arcsec/pxl | 1,2,3  | VRI; BVRI; VRI  |
| Nov. 08, 1986 | CTIO   | RCA  | 0.60 arcsec/pxl | 1,2    | BV; BV           |
| Nov. 09, 1986 | CTIO   | RCA  | 0.60 arcsec/pxl | 1,2,3  | VRI; VRI; BVRI  |
| Sept. 24, 1987| CTIO   | RCA  | 0.60 arcsec/pxl | 1,2,3  | BVRI; BV; BV     |
| Oct. 13, 1987 | CTIO   | RCA  | 0.60 arcsec/pxl | 1,2,3  | B; BVRI; BVRI   |
| Oct. 22, 1987 | CTIO   | RCA  | 0.60 arcsec/pxl | 1,2    | BVRI; BVI      |
| Nov. 21, 1987 | CTIO   | RCA  | 0.60 arcsec/pxl | 1,2    | BV; B; V       |
| Nov. 25, 1987 | CTIO   | RCA  | 0.60 arcsec/pxl | 1,2,3  | VRI; VRI; VRI  |
| Sept. 10, 1988| CTIO   | RCA  | 0.60 arcsec/pxl | 1,2,3  | BVRI; BVRI; BV  |
| Sept. 15, 1988| CTIO   | RCA  | 0.60 arcsec/pxl | 1,2,3  | BVI; BV; BV     |
| Oct. 07, 1988 | CTIO   | RCA  | 0.60 arcsec/pxl | 1,2,3  | BVRI; VRI; BVRI |
| Oct. 13, 1988 | CTIO   | RCA  | 0.60 arcsec/pxl | 1,2,3  | VRI; BVRI; VRI  |
| Nov. 07, 1988 | CTIO   | RCA  | 0.60 arcsec/pxl | 1,2,3  | BV; BV; BV      |
| Sept. 10, 1991 | LCO   | FORD1| 0.16 arcsec/pxl | 1,2,3  | R; R; VR       |
| Sept. 11, 1991 | LCO   | FORD1| 0.16 arcsec/pxl | 1,2,3  | BVRI; BVRI; BVRI|
| Sept. 12, 1991 | LCO   | FORD1| 0.16 arcsec/pxl | 1,2,3  | BVRI; BVRI; BVRI|
| Sept. 13, 1991 | LCO   | FORD1| 0.16 arcsec/pxl | 1,2,3  | BVRI; BVRI; BVRI|
| Sept. 14, 1991 | LCO   | FORD1| 0.16 arcsec/pxl | 1,2,3  | BVRI; BVRI; BVRI|
| Oct. 02, 1992 | LCO    | TEK4 | 0.26 arcsec/pxl | 1,2,3  | BVRI; BVRI; BVRI|
| Oct. 03, 1992 | LCO    | TEK4 | 0.26 arcsec/pxl | 1,2,3  | BVRI; BVRI; VRI |
| Nov. 20, 1992 | LCO    | TEK4 | 0.26 arcsec/pxl | 1,2    | BVRI; RI       |
Table 2—Continued

| Date(UT)    | Telescope | Chip  | Scale            | Fields | Filters   |
|-------------|-----------|-------|------------------|--------|-----------|
| Nov. 21, 1992 | LCO       | TEK4  | 0.26 arcsec/pixl | 2,3    | BV R; BVRI |
| Dec. 20, 1992 | LCO       | TEK3  | 0.23 arcsec/pixl | 3      | BVRI      |
| Dec. 21, 1992 | LCO       | TEK3  | 0.23 arcsec/pixl | 2      | BVRI      |
| Dec. 22, 1992 | LCO       | TEK3  | 0.23 arcsec/pixl | 1,3    | VRI; BVRI |

Table 3. Positions for [MF09] Cepheids

| Name                  | P(days) | RA (2000)  | DEC (2000) |
|-----------------------|---------|------------|------------|
| NGC 0247:[MF09] C1    | 65.86   | 00:47:10.6 | -20:40:11  |
| NGC 0247:[MF09] C2    | 48.53   | 00:47:03.8 | -20:41:04  |
| NGC 0247:[MF09] C3    | 48.38   | 00:47:10.5 | -20:47:21  |
| NGC 0247:[MF09] C4    | 33.23   | 00:47:10.1 | -20:48:45  |
| NGC 0247:[MF09] C5    | 30.931  | 00:47:03.5 | -20:47:59  |
| NGC 0247:[MF09] C6    | 27.785  | 00:47:07.6 | -20:37:51  |
| NGC 0247:[MF09] C7    | 26.2    | 00:47:01.1 | -20:39:12  |
| NGC 0247:[MF09] C8    | 22.3    | 00:47:01.1 | -20:37:58  |
| NGC 0247:[MF09] C9    | 20.2    | 00:47:01.4 | -20:39:55  |
Table 4. Observations of C1 (P = 69.9 days)

| Filter | Mag. | Error | Julian Day   |
|--------|------|-------|--------------|
|        |      |       |              |
| B      |      |       |              |
| 22.23  | 0.03 |       | 2447441.6878|
| 21.82  | 0.02 |       | 2446407.6021|
| 22.30  | 0.04 |       | 2447120.5347|
| 22.45  | 0.04 |       | 2447472.5924|
| 22.23  | 0.04 |       | 2447090.5611|
| 22.66  | 0.05 |       | 2446728.6868|
| 22.71  | 0.10 |       | 2447414.7347|
| 22.57  | 0.09 |       | 2447419.6694|
| 22.71  | 0.08 |       | 2447062.6007|
| 22.24  | 0.06 |       | 2446743.6097|
| 22.03  | 0.04 |       | 2448510.6653|
| 21.98  | 0.02 |       | 2448511.7306|
| 22.01  | 0.03 |       | 2448512.7177|
| 22.04  | 0.03 |       | 2448513.7368|
| 22.46  | 0.09 |       | 2448946.6891|
| 22.39  | 0.09 |       | 2448898.8180|
| V      |      |       |              |
| 21.20  | 0.02 |       | 2447441.6847|
| 20.91  | 0.02 |       | 2446407.6208|
| 21.19  | 0.03 |       | 2447120.5403|
| 21.37  | 0.03 |       | 2447472.5979|
| 21.28  | 0.03 |       | 2447090.5708|
| 21.48  | 0.04 |       | 2446728.6819|
| 21.64  | 0.05 |       | 2447414.7306|
| 21.44  | 0.04 |       | 2447419.6653|
| 21.22  | 0.03 |       | 2447062.5917|
| 21.23  | 0.04 |       | 2446743.6229|
| 21.08  | 0.03 |       | 2448510.6576|
| 21.06  | 0.02 |       | 2448511.7323|
| Filter | Mag. | Error | Julian Day  |
|--------|------|-------|------------|
| 21.06  | 0.02 |       | 2448512.7198 |
| 21.10  | 0.02 |       | 2448513.6840 |
| 21.26  | 0.02 |       | 2448946.6490 |
| 21.40  | 0.03 |       | 2448898.8294 |
| 21.41  | 0.03 |       | 2448897.6504 |
| 21.03  | 0.06 |       | 2448514.7785 |
| 20.92  | 0.02 |       | 2446406.6125 |
| 20.10  | 0.02 |       | 2446408.6236 |
| 21.18  | 0.03 |       | 2447124.6278 |
| 21.19  | 0.04 |       | 2446743.6250 |
| 21.51  | 0.03 |       | 2446729.5938 |
| 20.95  | 0.03 |       | 2446328.6632 |
| 20.92  | 0.02 |       | 2446329.6243 |
| 20.88  | 0.03 |       | 2446331.5681 |
| 20.89  | 0.04 |       | 2446332.5826 |
| 20.87  | 0.02 |       | 2447447.6328 |
| 21.36  | 0.05 |       | 2448978.5743 |

\( R \)

| Filter | Mag. | Error | Julian Day  |
|--------|------|-------|------------|
| 20.60  | 0.01 |       | 2447441.6910 |
| 20.72  | 0.03 |       | 2447090.5514 |
| 20.75  | 0.02 |       | 2447414.7417 |
| 20.58  | 0.03 |       | 2447062.5854 |
| 20.57  | 0.03 |       | 2448510.6493 |
| 20.60  | 0.01 |       | 2448511.7340 |
| 20.55  | 0.02 |       | 2448512.7198 |
| 20.55  | 0.02 |       | 2448513.6924 |
| 20.79  | 0.01 |       | 2448946.6623 |
| 20.79  | 0.02 |       | 2448897.6596 |
| 20.81  | 0.02 |       | 2448898.8385 |
| 20.57  | 0.02 |       | 2448509.8417 |
| Filter | Mag. | Error | Julian Day |
|--------|------|-------|------------|
| 20.75  | 0.02 | 2446029.5344 |
| 20.40  | 0.02 | 2446406.6069 |
| 20.44  | 0.01 | 2446408.6146 |
| 20.65  | 0.02 | 2447124.6236 |
| 20.66  | 0.02 | 244744.6194  |
| 20.91  | 0.02 | 2446729.5833 |
| 20.42  | 0.02 | 2446328.6771 |
| 20.40  | 0.02 | 2446329.6389 |
| 20.45  | 0.01 | 2447447.6472 |
| 20.73  | 0.04 | 2448978.6041 |
| 20.02  | 0.02 | 2447441.6965 |
| 20.20  | 0.04 | 2447090.5556 |
| 20.09  | 0.08 | 2447062.5819 |
| 20.02  | 0.03 | 2448510.6410 |
| 20.04  | 0.02 | 2448511.7337 |
| 20.04  | 0.03 | 2448512.8333 |
| 20.07  | 0.03 | 2448513.7007 |
| 20.18  | 0.02 | 2448946.6748 |
| 20.07  | 0.02 | 2448997.6686 |
| 20.13  | 0.03 | 2448898.8482 |
| 19.89  | 0.03 | 2446407.6104 |
| 20.08  | 0.05 | 2447124.6375 |
| 20.11  | 0.04 | 2446744.6153 |
| 20.24  | 0.04 | 2446729.5875 |
| 20.15  | 0.03 | 2447419.6590 |
| 19.83  | 0.05 | 2446328.6528 |
| 19.94  | 0.02 | 2447447.6528 |
| 20.12  | 0.04 | 2448978.6166 |
Table 5. Observations of C2 (P = 48.3 days)

| Filter | Mag. | Error | Julian Day   |
|--------|------|-------|--------------|
| B      |      |       |              |
| 22.19  | 0.03 |       | 2447441.6878 |
| 23.00  | 0.09 |       | 2447120.5347 |
| 23.37  | 0.11 |       | 2447472.5924 |
| 23.34  | 0.12 |       | 2447419.6694 |
| 22.42  | 0.07 |       | 2447062.6007 |
| 22.49  | 0.07 |       | 2448510.6653 |
| 22.35  | 0.04 |       | 2448511.7306 |
| 22.47  | 0.04 |       | 2448512.7177 |
| 22.38  | 0.04 |       | 2448513.7368 |
| 22.20  | 0.07 |       | 2448946.6891 |
| 22.30  | 0.09 |       | 2448897.6395 |
| 22.26  | 0.09 |       | 2448898.8180 |
| V      |      |       |              |
| 21.52  | 0.02 |       | 2447441.6847 |
| 21.95  | 0.05 |       | 2447120.5403 |
| 22.35  | 0.09 |       | 2447472.5979 |
| 22.03  | 0.09 |       | 2447414.7306 |
| 22.15  | 0.04 |       | 2447419.6653 |
| 21.67  | 0.06 |       | 2447062.5917 |
| 21.69  | 0.06 |       | 2448510.6576 |
| 21.71  | 0.04 |       | 2448511.7323 |
| 21.66  | 0.04 |       | 2448512.7198 |
| 21.69  | 0.05 |       | 2448513.6840 |
| 21.53  | 0.04 |       | 2448946.6490 |
| 21.60  | 0.03 |       | 2448898.8294 |
| 21.56  | 0.04 |       | 2448897.6504 |
| 21.57  | 0.10 |       | 2448514.7785 |
| 21.58  | 0.03 |       | 2447447.6328 |
| 22.40  | 0.12 |       | 2448978.5743 |
| Filter | Mag. | Error | Julian Day |
|--------|------|-------|-----------|
| $R$    |      |       |           |
| 21.17  | 0.02 |       | 2447441.6910 |
| 21.14  | 0.04 |       | 2447062.5854 |
| 21.21  | 0.04 |       | 2448510.6493 |
| 21.29  | 0.05 |       | 2448511.7340 |
| 21.28  | 0.03 |       | 2448512.7198 |
| 21.32  | 0.03 |       | 2448513.6924 |
| 21.15  | 0.02 |       | 2448946.6623 |
| 21.24  | 0.03 |       | 2448897.6596 |
| 21.21  | 0.04 |       | 2448898.8385 |
| 21.25  | 0.03 |       | 2448509.8417 |
| 21.20  | 0.03 |       | 2447447.6472 |
| 21.74  | 0.10 |       | 2448978.6041 |
| $I$    |      |       |           |
| 20.80  | 0.04 |       | 2447441.6965 |
| 20.99  | 0.14 |       | 2447062.5819 |
| 20.83  | 0.08 |       | 2448510.6410 |
| 20.82  | 0.05 |       | 2448511.7337 |
| 20.94  | 0.06 |       | 2448512.8333 |
| 20.89  | 0.06 |       | 2448513.7007 |
| 20.78  | 0.04 |       | 2448946.6748 |
| 20.81  | 0.04 |       | 2448897.6686 |
| 20.94  | 0.07 |       | 2448898.8482 |
| 21.32  | 0.07 |       | 2447419.6590 |
| 20.88  | 0.04 |       | 2447447.6528 |
| 21.38  | 0.13 |       | 2448978.6166 |
Table 6. Observations of C3 (P = 44.3 days)

| Filter | Mag. | Error | Julian Day |
|--------|------|-------|------------|
|        | 23.72| 0.17  | 2447447.6618 |
|        | 23.33| 0.20  | 2448510.6931 |
|        | 23.64| 0.17  | 2448511.6833 |
|        | 23.47| 0.19  | 2448513.6597 |
|        | 22.58| 0.14  | 2448977.5926 |
|        | 23.08| 0.14  | 2448947.5667 |
|        | 23.41| 0.18  | 2448897.6799 |
|        | 23.02| 0.06  | 2446407.5903 |
|        | 23.23| 0.12  | 2447120.5535 |
|        | 23.09| 0.15  | 2446729.6028 |
|        | 22.17| 0.16  | 2447062.6222 |
|        | 22.46| 0.07  | 2447441.6278 |
|        | 22.65| 0.13  | 2447447.6688 |
|        | 22.70| 0.14  | 2448510.7049 |
|        | 22.76| 0.12  | 2448511.6750 |
|        | 22.55| 0.10  | 2448512.7733 |
|        | 22.60| 0.10  | 2448513.7504 |
|        | 21.88| 0.06  | 2447419.6910 |
|        | 21.96| 0.04  | 2446407.5799 |
|        | 22.07| 0.04  | 2446408.5924 |
|        | 22.24| 0.06  | 2447120.5597 |
|        | 22.26| 0.08  | 2447124.6528 |
|        | 22.00| 0.12  | 2447472.6056 |
|        | 22.61| 0.15  | 2446744.6312 |
|        | 22.57| 0.12  | 2447090.5771 |
|        | 22.34| 0.09  | 2446729.5993 |
|        | 21.54| 0.10  | 2447414.7715 |
|        | 22.36| 0.11  | 2446330.6319 |
| Filter | Mag. | Error | Julian Day |
|--------|------|-------|-----------|
|        | 22.24| 0.16  | 2446331.5819 |
|        | 21.76| 0.05  | 2447062.6278 |
|        | 22.22| 0.05  | 2448947.5213 |
|        | 21.76| 0.07  | 2448977.5428 |
|        | 22.19| 0.08  | 2448897.6872 |
| $R$    | 21.87| 0.05  | 2447441.6340 |
|        | 22.02| 0.08  | 2447447.6764 |
|        | 22.20| 0.08  | 2448511.6674 |
|        | 22.04| 0.06  | 2448513.7535 |
|        | 21.65| 0.14  | 2448977.5622 |
|        | 21.84| 0.03  | 2448947.5392 |
|        | 21.68| 0.04  | 2448897.6998 |
|        | 21.91| 0.05  | 2446729.6097 |
|        | 22.00| 0.08  | 2448512.6653 |
|        | 22.00| 0.08  | 2448509.8576 |
|        | 21.55| 0.05  | 2446406.5993 |
|        | 21.51| 0.04  | 2446408.5833 |
|        | 21.75| 0.06  | 2447124.6479 |
|        | 22.11| 0.10  | 2446744.6368 |
|        | 21.72| 0.09  | 2446329.6562 |
|        | 21.62| 0.09  | 2447081.5653 |
|        | 21.68| 0.04  | 2448946.7196 |
| $I$    | 21.20| 0.07  | 2447441.6396 |
|        | 21.34| 0.09  | 2447447.6819 |
|        | 21.63| 0.12  | 2448510.7201 |
|        | 21.57| 0.09  | 2448511.6583 |
|        | 20.84| 0.09  | 2448977.5759 |
Table 6—Continued

| Filter | Mag. | Error | Julian Day  |
|--------|------|-------|------------|
| 21.28  | 0.05 | 2448947.5525 |
| 20.95  | 0.05 | 2448897.7084 |
| 21.39  | 0.12 | 2446729.6139 |
| 21.03  | 0.07 | 2446407.6347 |
| 21.18  | 0.10 | 2447124.6438 |
| 21.37  | 0.12 | 2446744.6417 |
| 21.30  | 0.11 | 2447090.5882 |
| 21.73  | 0.16 | 2446330.6611 |
| 21.02  | 0.11 | 2448898.8788 |
| 21.18  | 0.07 | 2448946.7350 |
Table 7. Observations of C4 (P = 33.2 days)

| Filter | Mag. | Error | Julian Day |
|--------|------|-------|------------|
|        |      |       |            |
|        |      |       | B          |
|        |      |       | 23.10      | 0.09 | 2447447.6618 |
|        |      |       | 23.29      | 0.12 | 2448510.6931 |
|        |      |       | 23.33      | 0.10 | 2448511.6833 |
|        |      |       | 23.62      | 0.17 | 2448513.6597 |
|        |      |       | 22.82      | 0.15 | 2448977.5926 |
|        |      |       | 23.34      | 0.18 | 2448947.5667 |
|        |      |       | 22.88      | 0.10 | 2448897.6799 |
|        |      |       | 22.04      | 0.12 | 2448898.8590 |
|        |      |       | 22.40      | 0.05 | 2446407.5903 |
|        |      |       | 23.19      | 0.13 | 2447120.5535 |
|        |      |       | 22.58      | 0.11 | 2446743.6340 |
|        |      |       | 22.60      | 0.10 | 2448898.6477 |
|        |      |       | V          |
|        |      |       | 22.00      | 0.05 | 2447441.6278 |
|        |      |       | 22.12      | 0.06 | 2447447.6688 |
|        |      |       | 22.27      | 0.08 | 2448510.7049 |
|        |      |       | 22.29      | 0.09 | 2448511.6750 |
|        |      |       | 22.20      | 0.06 | 2448512.7733 |
|        |      |       | 22.20      | 0.08 | 2448513.7504 |
|        |      |       | 22.37      | 0.08 | 2447419.6868 |
|        |      |       | 22.36      | 0.12 | 2447081.5562 |
|        |      |       | 22.46      | 0.08 | 2447419.6910 |
|        |      |       | 21.86      | 0.05 | 2446407.5799 |
|        |      |       | 21.83      | 0.06 | 2446408.5924 |
|        |      |       | 22.43      | 0.06 | 2447120.5597 |
|        |      |       | 22.54      | 0.08 | 2447124.6528 |
|        |      |       | 21.81      | 0.07 | 2447472.6056 |
|        |      |       | 21.89      | 0.07 | 2446743.6403 |
|        |      |       | 22.03      | 0.09 | 2446744.6312 |
Table 7—Continued

| Filter | Mag. | Error | Julian Day   |
|--------|------|-------|--------------|
|        |      |       |              |
| 22.62  | 0.10 | 2447090.5771 |
| 22.45  | 0.08 | 2446729.5993 |
| 22.00  | 0.09 | 2447414.7715 |
| 22.41  | 0.10 | 2446329.6688 |
| 22.41  | 0.08 | 2446330.6319 |
| 22.57  | 0.18 | 2446331.5819 |
| 22.74  | 0.12 | 2447062.6278 |
| 22.44  | 0.05 | 2448947.5213 |
| 21.83  | 0.07 | 2448898.8663 |
| 22.27  | 0.12 | 2448977.5428 |
| 22.05  | 0.06 | 2448897.6872 |
|        |      |       |              |
| $R$    |      |       |              |
| 21.70  | 0.09 | 2447441.6340 |
| 21.94  | 0.06 | 2448510.7125 |
| 21.94  | 0.08 | 2448511.6674 |
| 21.83  | 0.05 | 2448513.7535 |
| 21.49  | 0.12 | 2448977.5622 |
| 22.12  | 0.04 | 2448947.5392 |
| 21.86  | 0.04 | 2448897.6998 |
| 21.74  | 0.04 | 2448898.6209 |
| 22.18  | 0.09 | 2446729.6097 |
| 21.78  | 0.07 | 2448512.6653 |
| 21.67  | 0.05 | 2448509.8576 |
| 21.69  | 0.05 | 2446406.5993 |
| 21.63  | 0.07 | 2446408.5833 |
| 21.90  | 0.06 | 2447124.6479 |
| 21.62  | 0.06 | 2446744.6368 |
| 21.70  | 0.08 | 2447081.5653 |
| 22.13  | 0.06 | 2448946.7196 |

$I$
Table 7—Continued

| Filter | Mag. | Error | Julian Day |
|--------|------|-------|------------|
| 21.07  | 0.07 |       | 2447441.6396 |
| 21.36  | 0.08 |       | 2448510.7201 |
| 21.20  | 0.08 |       | 2448511.6583 |
| 21.40  | 0.08 |       | 2448513.6340 |
| 20.86  | 0.11 |       | 2448977.5759 |
| 21.44  | 0.06 |       | 2448947.5525 |
| 21.70  | 0.10 |       | 2448897.7084 |
| 21.53  | 0.10 |       | 2448898.6084 |
| 21.12  | 0.08 |       | 2446407.6347 |
| 20.93  | 0.16 |       | 2447081.5694 |
| 21.58  | 0.09 |       | 2448946.7350 |
Table 8. Observations of C5 (P = 31.0 days)

| Filter | Mag.  | Error | Julian Day   |
|--------|-------|-------|--------------|
|        |       |       |              |
| $B$    |       |       |              |
| 23.45  | 0.13  | 2447447.6618 |
| 22.72  | 0.08  | 2448510.6931 |
| 22.56  | 0.07  | 2448511.6833 |
| 22.62  | 0.06  | 2448512.7618 |
| 22.95  | 0.12  | 2448513.6597 |
| 22.85  | 0.20  | 2448977.5926 |
| 23.08  | 0.04  | 2448947.5667 |
| 22.78  | 0.06  | 2446407.5903 |
| 23.10  | 0.10  | 2447120.5535 |
| 22.97  | 0.10  | 2447090.5819 |
| 23.53  | 0.16  | 2446729.6028 |
| 23.64  | 0.12  | 2447419.6812 |
| 22.81  | 0.20  | 2448898.6477 |
| $V$    |       |       |              |
| 22.76  | 0.08  | 2447441.6278 |
| 23.15  | 0.12  | 2447447.6688 |
| 22.28  | 0.08  | 2448510.7049 |
| 22.28  | 0.08  | 2448511.6750 |
| 22.27  | 0.07  | 2448512.7733 |
| 22.17  | 0.06  | 2448513.7504 |
| 22.89  | 0.10  | 2447419.6868 |
| 23.06  | 0.16  | 2447419.6910 |
| 22.21  | 0.06  | 2446406.5903 |
| 22.21  | 0.05  | 2446407.5799 |
| 22.33  | 0.06  | 2446408.5924 |
| 22.35  | 0.06  | 2447120.5597 |
| 22.38  | 0.08  | 2447124.6528 |
| 22.74  | 0.18  | 2447472.6056 |
| 22.42  | 0.11  | 2446743.6403 |
Table 8—Continued

| Filter | Mag. | Error | Julian Day  |
|--------|------|-------|------------|
|        | 22.26| 0.12  | 2446744.6312 |
|        | 22.30| 0.07  | 2447090.5771 |
|        | 22.66| 0.09  | 2446729.5993 |
|        | 22.92| 0.15  | 2446330.6319 |
|        | 22.49| 0.09  | 2447062.6278 |
|        | 22.30| 0.04  | 2448947.5213 |
|        | 22.63| 0.13  | 2448898.8663 |
|        | 22.25| 0.11  | 2448977.5428 |
|        | 22.56| 0.09  | 2448897.6872 |
|        | 22.32| 0.09  | 2447441.6340 |
|        | 22.55| 0.09  | 2447447.6764 |
|        | 22.06| 0.07  | 2448510.7125 |
|        | 22.01| 0.07  | 2448511.6674 |
|        | 22.05| 0.06  | 2448513.7535 |
|        | 21.91| 0.17  | 2448977.5622 |
|        | 22.03| 0.04  | 2448947.5392 |
|        | 22.37| 0.07  | 2448897.6998 |
|        | 22.58| 0.08  | 2448898.6209 |
|        | 22.34| 0.09  | 2446729.6097 |
|        | 21.85| 0.06  | 2448512.6653 |
|        | 22.00| 0.06  | 2448509.8576 |
|        | 22.04| 0.07  | 2446406.5993 |
|        | 22.09| 0.06  | 2446408.5833 |
|        | 22.10| 0.08  | 2447124.6479 |
|        | 21.99| 0.08  | 2446744.6368 |
|        | 22.44| 0.12  | 2446329.6562 |
|        | 21.93| 0.04  | 2448946.7196 |
|        | 21.99| 0.14  | 2447441.6396 |
Table 8—Continued

| Filter | Mag. | Error | Julian Day   |
|--------|------|-------|--------------|
| 21.78  | 0.12 |       | 2447447.6819|
| 21.47  | 0.08 |       | 2448510.7201|
| 21.41  | 0.08 |       | 2448511.6583|
| 21.53  | 0.08 |       | 2448513.6340|
| 21.51  | 0.17 |       | 2448977.5759|
| 21.61  | 0.06 |       | 2448947.5525|
| 22.04  | 0.14 |       | 2448897.7084|
| 21.78  | 0.14 |       | 2448898.6084|
| 21.94  | 0.21 |       | 2446729.6139|
| 21.55  | 0.11 |       | 2446407.6347|
| 21.74  | 0.18 |       | 2447124.6438|
| 21.49  | 0.15 |       | 2446744.6417|
| 21.56  | 0.12 |       | 2447090.5882|
| 21.63  | 0.14 |       | 2446330.6611|
| 21.53  | 0.07 |       | 2448946.7350|
Table 9. Observations of C6 (P = 30.1 days)

| Filter | Mag. | Error | Julian Day   |
|--------|------|-------|--------------|
| B      | 22.77| 0.05  | 2447441.6653 |
|        | 22.86| 0.10  | 2448510.7882 |
|        | 23.06| 0.09  | 2448511.6944 |
|        | 22.88| 0.10  | 2447062.6361 |
|        | 22.35| 0.05  | 2447472.6167 |
|        | 23.29| 0.18  | 2446744.6611 |
|        | 22.77| 0.08  | 2447090.6125 |
|        | 22.22| 0.09  | 2447414.8458 |
|        | 22.45| 0.05  | 2447419.7062 |
|        | 22.26| 0.08  | 2447081.6049 |
|        | 22.56| 0.09  | 2448976.6208 |
|        | 22.24| 0.12  | 2448978.6345 |
|        | 22.13| 0.09  | 2448947.6249 |
|        | 22.96| 0.17  | 2448897.7201 |
| V      | 22.28| 0.04  | 2447441.6590 |
|        | 22.25| 0.11  | 2448510.7826 |
|        | 22.64| 0.10  | 2448511.7069 |
|        | 22.53| 0.08  | 2448512.7764 |
|        | 22.65| 0.10  | 2448513.7483 |
|        | 22.23| 0.10  | 2448509.8903 |
|        | 22.22| 0.06  | 2447090.6083 |
|        | 21.88| 0.08  | 2447081.6007 |
|        | 22.57| 0.09  | 2447124.6708 |
|        | 22.03| 0.05  | 2447472.6229 |
|        | 22.95| 0.19  | 2446744.6569 |
|        | 22.36| 0.08  | 2446729.6292 |
|        | 21.90| 0.09  | 2447414.8403 |
|        | 22.04| 0.04  | 2447419.7021 |
| Filter | Mag. | Error | Julian Day  |
|--------|------|-------|-------------|
| R      |      |       |             |
| 21.94  | 0.04 |       | 2447441.6528 |
| 21.82  | 0.05 |       | 2448510.7583 |
| 22.04  | 0.08 |       | 2448511.7153 |
| 21.91  | 0.05 |       | 2448512.7781 |
| 21.88  | 0.05 |       | 2448513.7521 |
| 21.72  | 0.05 |       | 2448509.8750 |
| 21.88  | 0.06 |       | 2447124.6764 |
| 22.39  | 0.12 |       | 2446744.6521 |
| 21.76  | 0.05 |       | 2447090.6000 |
| 21.68  | 0.05 |       | 2446729.6201 |
| 21.50  | 0.08 |       | 2447081.5917 |
| 21.60  | 0.04 |       | 2447447.6965 |
| 21.50  | 0.09 |       | 2448976.6483 |
| 21.60  | 0.03 |       | 2448947.5974 |
| 21.70  | 0.05 |       | 2448897.7402 |
| 21.74  | 0.05 |       | 2448898.6700 |
| I      |      |       |             |
| 21.54  | 0.08 |       | 2447441.6479 |
| 21.59  | 0.11 |       | 2448510.7417 |
| 21.38  | 0.07 |       | 2448511.7229 |
| 21.66  | 0.12 |       | 2448513.5979 |
| 21.55  | 0.06 |       | 2448512.7778 |
Table 9—Continued

| Filter | Mag. | Error | Julian Day |
|--------|------|-------|------------|
| 21.42  | 0.16 |       | 2447124.6812 |
| 21.55  | 0.15 |       | 2447090.5958 |
| 21.58  | 0.16 |       | 2446729.6243 |
| 21.32  | 0.07 |       | 2447447.6910 |
| 21.15  | 0.09 |       | 2448976.6609 |
| 21.32  | 0.05 |       | 2448947.6100 |
| 21.53  | 0.09 |       | 2448897.7494 |
| 21.44  | 0.06 |       | 2448898.6607 |
Table 10. Observations of C7 (P = 26.1 days)

| Filter | Mag. | Error | Julian Day |
|--------|------|-------|------------|
|        |      |       |            |
| B      |      |       |            |
| 23.50  | 0.07 |       | 2447441.6878 |
| 23.00  | 0.05 |       | 2446407.6021 |
| 22.99  | 0.07 |       | 2447472.5924 |
| 23.27  | 0.10 |       | 2447090.5611 |
| 23.75  | 0.11 |       | 2446728.6868 |
| 22.81  | 0.05 |       | 2447419.6694 |
| 22.98  | 0.11 |       | 2446743.6097 |
| 23.32  | 0.13 |       | 2448512.7121 |
| 22.68  | 0.13 |       | 2448513.6222 |
| V      |      |       |            |
| 23.19  | 0.10 |       | 2447441.6847 |
| 22.40  | 0.05 |       | 2446407.6208 |
| 22.72  | 0.12 |       | 2447472.5979 |
| 22.88  | 0.09 |       | 2447090.5708 |
| 22.96  | 0.12 |       | 2446728.6819 |
| 22.81  | 0.20 |       | 2447414.7306 |
| 22.55  | 0.07 |       | 2447419.6653 |
| 22.95  | 0.18 |       | 2447062.5917 |
| 22.50  | 0.13 |       | 2446743.6229 |
| 22.68  | 0.12 |       | 2448512.7024 |
| 22.53  | 0.13 |       | 2448513.6168 |
| 23.00  | 0.12 |       | 2448946.6490 |
| 23.23  | 0.17 |       | 2448898.8294 |
| 22.45  | 0.06 |       | 2446406.6125 |
| 22.47  | 0.06 |       | 2446408.6236 |
| 23.19  | 0.15 |       | 2447124.6278 |
| 22.43  | 0.13 |       | 2446743.6250 |
| 23.06  | 0.12 |       | 2446729.5938 |
| 22.86  | 0.18 |       | 2446331.5681 |
Table 10—Continued

| Filter | Mag.  | Error | Julian Day |
|--------|-------|-------|------------|
|        | 22.40 | 0.05  | 2447447.6328 |
|        | 23.04 | 0.18  | 2448978.5743 |
|        | 23.26 | 0.18  | 2448509.8903 |
|        | 22.66 | 0.05  | 2447441.6910 |
|        | 22.29 | 0.09  | 2447090.5514 |
|        | 22.25 | 0.13  | 2447062.5854 |
|        | 22.33 | 0.09  | 2448512.6941 |
|        | 22.31 | 0.09  | 2448513.6089 |
|        | 22.40 | 0.07  | 2448946.6623 |
|        | 22.85 | 0.10  | 2448897.6596 |
|        | 22.55 | 0.06  | 2446029.5344 |
|        | 22.14 | 0.06  | 2446406.6069 |
|        | 22.13 | 0.06  | 2446408.6146 |
|        | 22.46 | 0.09  | 2447124.6236 |
|        | 22.26 | 0.10  | 2446744.6194 |
|        | 22.53 | 0.09  | 2446729.5833 |
|        | 22.19 | 0.08  | 2446328.6771 |
|        | 22.57 | 0.13  | 2446329.6389 |
|        | 22.10 | 0.04  | 2447447.6472 |
|        | 22.66 | 0.02  | 2448978.6041 |
|        | 22.94 | 0.13  | 2448509.8810 |
|        | 22.51 | 0.15  | 2447441.6965 |
|        | 22.14 | 0.02  | 2447090.5556 |
|        | 21.74 | 0.09  | 2448946.6748 |
|        | 22.24 | 0.14  | 2448897.6686 |
|        | 21.78 | 0.13  | 2446407.6104 |
|        | 21.68 | 0.16  | 2446744.6153 |
|        | 22.02 | 0.19  | 2446729.5875 |
Table 10—Continued

| Filter | Mag. | Error | Julian Day     |
|--------|------|-------|----------------|
| 21.83  | 0.11 |       | 2447419.6590   |
| 21.93  | 0.13 |       | 2447447.6528   |
Table 11. Observations of C8 (P = 22.3 days)

| Filter | Mag.  | Error | Julian Day   |
|--------|-------|-------|--------------|
|        |       |       |              |
| $B$    |       |       |              |
| 23.76  | 0.09  | 2447441.6653 |
| 23.57  | 0.11  | 2448511.6944 |
| 23.97  | 0.02  | 2447062.6361 |
| 24.18  | 0.02  | 2447472.6167 |
| 22.63  | 0.10  | 2446744.6611 |
| 23.84  | 0.18  | 2447090.6125 |
| 23.65  | 0.13  | 2447419.7062 |
| $V$    |       |       |              |
| 22.82  | 0.07  | 2447441.6590 |
| 22.77  | 0.15  | 2448510.7826 |
| 23.10  | 0.03  | 2448511.7069 |
| 22.94  | 0.11  | 2448512.7764 |
| 23.07  | 0.15  | 2448513.7483 |
| 22.88  | 0.18  | 2448509.8903 |
| 23.29  | 0.15  | 2447090.6083 |
| 22.51  | 0.14  | 2447081.6007 |
| 22.25  | 0.07  | 2447124.6708 |
| 23.22  | 0.15  | 2447472.6229 |
| 22.28  | 0.09  | 2446744.6569 |
| 23.22  | 0.15  | 2446729.6292 |
| 22.92  | 0.08  | 2447419.7021 |
| 22.80  | 0.12  | 2447062.6458 |
| 23.25  | 0.15  | 2447447.7035 |
| 22.47  | 0.13  | 2448978.6484 |
| 23.26  | 0.12  | 2448947.5844 |
| 23.42  | 0.18  | 2448897.7311 |
| 23.34  | 0.19  | 2448898.6789 |
| $R$    |       |       |              |
| 22.37  | 0.05  | 2447441.6528 |
Table 11—Continued

| Filter | Mag. | Error | Julian Day   |
|--------|------|-------|--------------|
| 22.18  | 0.10 |       | 2448510.7583|
| 22.51  | 0.12 |       | 2448511.7153|
| 22.44  | 0.09 |       | 2448512.7781|
| 22.54  | 0.10 |       | 2448513.7521|
| 22.35  | 0.09 |       | 2448509.8750|
| 21.88  | 0.06 |       | 2447124.6764|
| 22.05  | 0.08 |       | 2446744.6521|
| 22.81  | 0.10 |       | 2447090.6    |
| 22.53  | 0.10 |       | 2446729.6201|
| 22.32  | 0.16 |       | 2447081.5917|
| 22.62  | 0.08 |       | 2447447.6965|
| 22.04  | 0.14 |       | 2448978.6613|
| 22.94  | 0.12 |       | 2448947.5974|
| 22.62  | 0.10 |       | 2448897.7402|

$I$

| Filter | Mag. | Error | Julian Day   |
|--------|------|-------|--------------|
| 21.98  | 0.10 |       | 2447441.6479|
| 22.05  | 0.16 |       | 2448510.7417|
| 21.92  | 0.13 |       | 2448511.7229|
| 21.90  | 0.09 |       | 2448512.7778|
| 21.36  | 0.14 |       | 2447124.6812|
| 22.13  | 0.29 |       | 2446744.6479|
| 21.89  | 0.18 |       | 2446729.6243|
| 21.59  | 0.18 |       | 2447414.8340|
| 22.37  | 0.16 |       | 2447447.6910|
| 22.35  | 0.13 |       | 2448947.6100|
Table 12. Observations of C9 (P = 20.2 days)

| Filter | Mag. | Error | Julian Day |
|--------|------|-------|------------|
| B      |      |       |            |
| 23.88  | 0.14 |       | 2447441.6878 |
| 23.74  | 0.13 |       | 2446407.6021 |
| 23.60  | 0.17 |       | 2447120.5347 |
| 23.80  | 0.17 |       | 2447472.5924 |
| 23.65  | 0.17 |       | 2447090.5611 |
| 23.90  | 0.19 |       | 2446728.6868 |
| 23.83  | 0.18 |       | 2447120.5403 |
| 22.82  | 0.12 |       | 2447419.6694 |
| 23.27  | 0.16 |       | 2446743.6097 |
| 23.04  | 0.15 |       | 2448946.6891 |
| V      |      |       |            |
| 23.25  | 0.11 |       | 2447441.6847 |
| 23.31  | 0.14 |       | 2446407.6208 |
| 23.27  | 0.18 |       | 2447120.5403 |
| 22.73  | 0.12 |       | 2447472.5979 |
| 23.06  | 0.15 |       | 2447090.5708 |
| 23.18  | 0.13 |       | 2446728.6819 |
| 22.84  | 0.19 |       | 2447414.7306 |
| 23.35  | 0.16 |       | 2447419.6653 |
| 22.49  | 0.12 |       | 2447062.5917 |
| 22.81  | 0.17 |       | 2446743.6229 |
| 22.49  | 0.06 |       | 2448946.6490 |
| 23.26  | 0.16 |       | 2446406.6125 |
| 23.40  | 0.17 |       | 2446408.6236 |
| 22.53  | 0.11 |       | 2447124.6278 |
| 22.69  | 0.15 |       | 2446743.6250 |
| 23.46  | 0.20 |       | 2446729.5938 |
| 22.60  | 0.07 |       | 2447447.6328 |
Table 12—Continued

| Filter | Mag. | Error | Julian Day     |
|--------|------|-------|----------------|
| 22.86  | 0.10 |       | 2447441.6910  |
| 22.63  | 0.18 |       | 2447090.5514  |
| 22.62  | 0.12 |       | 2447414.7417  |
| 22.40  | 0.15 |       | 2447062.5854  |
| 22.43  | 0.06 |       | 2448946.6623  |
| 22.41  | 0.07 |       | 2446029.5344  |
| 22.87  | 0.15 |       | 2446406.6069  |
| 22.91  | 0.14 |       | 2446408.6146  |
| 22.36  | 0.10 |       | 2447124.6236  |
| 22.48  | 0.15 |       | 2446744.6194  |
| 22.72  | 0.12 |       | 2446729.5833  |
| 22.75  | 0.16 |       | 2446329.6389  |
| 22.30  | 0.06 |       | 2447447.6472  |
### Table 13. Properties of Unclassified Variables Found in NGC 0247

| ID      | Field | Coordinates<sup>a</sup> | P(?) (days) | <B> | <V> | <R> | <I> |
|---------|-------|--------------------------|-------------|-----|-----|-----|-----|
|         |       | x y                      |             | σ<sub>B</sub> | σ<sub>V</sub> | σ<sub>R</sub> | σ<sub>I</sub> |
| NGC 0247:[MF09] P1 | 1    | 227.0 223.4              | 14.4        | (23.49) | 21.56 | 20.66 | 19.59 |
|         |       |                          |             | 0.03   | 0.01  | 0.02  | 0.01  |
| NGC 0247:[MF09] P2 | 3    | 100.6 305.6              | 16.3        | (22.59) | 20.81 | 19.68 | 18.73 |
|         |       |                          |             | 0.03   | 0.01  | 0.01  | 0.01  |
| NGC 0247:[MF09] P3 | 3    | 104.4 090.7              | 28.4        | (23.53) | 21.49 | 20.26 | 19.14 |
|         |       |                          |             | 0.07   | 0.03  | 0.03  | 0.02  |
| NGC 0247:[MF09] P4 | 3    | 052.4 311.8              | 30.8        | (22.84) | 20.88 | 19.89 | 18.93 |
|         |       |                          |             | 0.03   | 0.02  | 0.01  | 0.01  |
| NGC 0247:[MF09] P5 | 2    | 178.3 149.8              | 63.2        | (23.10) | 22.09 | 21.54 | 21.01 |
|         |       |                          |             | 0.05   | 0.02  | 0.02  | 0.02  |

<sup>a</sup>Origin at bottom left (south-east) corner of frame
Table 14. Properties of NGC 0247 Cepheids

| ID          | Field | Coordinatesa, b | P (days) | $< B >$  | $\sigma_B$ | $< V >$  | $\sigma_V$ | $< R >$  | $\sigma_R$ | $< I >$  | $\sigma_I$ |
|-------------|-------|-----------------|----------|---------|------------|---------|------------|---------|------------|---------|------------|
| NGC 0247:[MF09] C1 | 1     | 097.8 474.5     | 69.9     | (22.31) | 0.08       | 21.21   | 0.04       | 20.65   | 0.03       | 20.07   | 0.02       |
| NGC 0247:[MF09] C2 | 1     | 011.6 250.5     | 48.3     | (22.77) | 0.13       | 21.92   | 0.07       | 21.51   | 0.05       | 21.11   | 0.07       |
| NGC 0247:[MF09] C3 | 2     | 211.7 302.1     | 44.3     | (22.99) | 0.13       | 21.78   | 0.07       | 21.81   | 0.05       | 21.19   | 0.05       |
| NGC 0247:[MF09] C4 | 2     | 069.4 290.9     | 33.2     | (22.86) | 0.09       | 22.12   | 0.04       | 21.79   | 0.04       | 21.28   | 0.02       |
| NGC 0247:[MF09] C5 | 2     | 151.1 130.1     | 31.0     | (23.11) | 0.08       | 22.59   | 0.05       | 22.23   | 0.04       | 21.68   | 0.04       |
| NGC 0247:[MF09] C6 | 3     | 055.5 362.2     | 30.1     | (22.82) | 0.11       | 22.37   | 0.07       | 21.84   | 0.06       | 21.44   | 0.03       |
| NGC 0247:[MF09] C7 | 1     | 196.9 201.3     | 26.1     | (23.30) | 0.12       | 22.79   | 0.06       | 22.36   | 0.04       | 22.03   | 0.09       |
| NGC 0247:[MF09] C8 | 3     | 044.7 187.1     | 22.3     | (23.52) | 0.20       | 22.93   | 0.08       | 22.50   | 0.08       | 22.06   | 0.09       |
| NGC 0247:[MF09] C9 | 1     | 125.4 208.0     | 20.2     | (23.49) | 0.12       | 22.93   | 0.09       | 22.57   | 0.06       | 22.06   | 0.09       |
a Origin at bottom left (south-east) corner of frame

b Scale = 0.6 arcsec/pixel
Table 15. Revised VI Magnitudes and Updated Periods for Cepheids in NGC 0247

| [MF09] ID | [GV08] ID | P (days) | $< V > \sigma_V$ | $< R > \sigma_R$ | $< I > \sigma_I$ |
|-----------|-----------|----------|-----------------|-----------------|-----------------|
| NGC 0247:[MF09] C1 | cep020 | 69.9 | 21.21 | 20.65 | 20.07 |
| NGC 0247:[MF09] C2 | cep017 | 48.3 | 21.92 | 21.51 | 21.11 |
| NGC 0247:[MF09] C3 | cep016 | 44.38 | 22.26 | 21.83 | 21.23 |
| NGC 0247:[MF09] C4 | cep011 | 33.23 | 22.12 | 21.79 | 21.28 |
| NGC 0247:[MF09] C5 | cep008 | 30.931 | 22.59 | 22.23 | 21.68 |
| NGC 0247:[MF09] C6 | cep005 | 27.785 | 22.42 | 21.77 | 21.65 |
| NGC 0247:[MF09] C7 | | 26.1 | 22.76 | 22.40 | 21.96 |
| NGC 0247:[MF09] C8 | | 22.3 | 22.88 | 22.38 | 21.91 |
| NGC 0247:[MF09] C9 | | 20.2 | 22.93 | 22.57 | … |
| | | | 0.09 | 0.06 | … |
Table 16. Summary of Cepheid Distance Moduli to NGC 0247

| Sample                  | No. & Bands | $\mu_o (\sigma)$ | D(Mpc) ($\sigma$) | E(V-I) ($\sigma$) |
|------------------------|-------------|------------------|--------------------|-------------------|
| Original [MF09] VRI Sample | 9 VRI       | 27.78 (0.13)     | 3.60 (0.22)        | 0.07 (0.05)       |
| Updated [MF09] VRI Sample | 9 VRI       | 27.81 (0.06)     | 3.65 (0.17)        | 0.07 (0.04)       |
| Updated [MF09] VI Sample | 9 VI        | 27.79 (0.13)     | 3.61 (0.23)        | 0.07 (0.04)       |
| Original [GV08] VI Sample | 17 VI       | 27.82 (0.08)     | 3.66 (0.14)        | 0.15 (0.03)       |
| Updated [GV08] VI Sample | 17 VI       | 27.87 (0.09)     | 3.75 (0.15)        | 0.11 (0.03)       |
| Updated & VI Merged Sample | 20 VI       | 27.85 (0.13)     | 3.72 (0.15)        | 0.11 (0.03)       |