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RR Lyrae Stars in the Globular NGC 3201: Light Curves, Reddening, and Distance

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Abstract. We present preliminary results of optical photometry of the nearby globular cluster NGC 3201 and its RR Lyrae variables.

1. Introduction

RR Lyrae stars (RRL) are a favourite standard candle for globular clusters and other old stellar populations, yet recent absolute magnitude calibrations, $M_V(RR)$, span more than 0.2 mag. Precise distance estimates for nearby globular clusters will eventually be available through satellite-based trigonometric parallaxes (Layden, 2001), thus providing a resolution to this old problem.

Here, we present a progress report on our high quality time-series photometry of RRL in the nearby globular cluster NGC 3201 – the first obtained for this cluster with a CCD. The resulting light curves provide accurate intensity-mean apparent magnitudes and reddening estimates, which will in turn be used to calibrate $M_V(RR)$ once a satellite-based parallax for NGC 3201 is available.

2. Observations, Reductions, and Variable Stars

Images of NGC 3201 were obtained in 1999 Feb using the YALO 1.0-m telescope at CTIO in queue mode. Each night, 1–3 visits were made to the cluster, and in each visit, B, V, I images were taken. A total of 42 visits were made over 20 nights. Photometric calibrations were obtained from seven visits on four nights, each yielding a fit with an RMS residual of 0.010–0.013 mag.

Photometry was performed with the DAOPHOT II, ALLSTAR, and ALLFRAME packages of Stetson (1994). Color magnitude diagrams in $(V,\ B-V)$ and $(V,\ V-I)$ were derived, each containing over 10^4 stars and extending from the red giant branch tip to over 1 mag below the main sequence turn-off. Broadened principal sequences are the result of differential reddening.

Variable stars were detected using the variability index produced by DAOMASTER (Stetson 1994). There were 58 candidate RRL, along with variables at the red giant branch tip and among the blue straggler stars. For each candidate RRL, we searched for a period on the range $0.2 < P < 0.9$ days using the template fitting method of Layden & Sarajedini (2000). Each of the 25 RRL candidates analyzed to date yielded a clear period and light curve. All known variables were detected, and three new RRL were discovered. For each RRL, we computed light curve parameters including intensity-mean magnitude ($\langle V \rangle$), V-amplitude, and colour at minimum-light ($0.5 < \phi < 0.8$).

3. Reddening and Distance

Sturch (1966) showed that, after minor corrections for metallicity and period, all ab-type RRL have the same $(B-V)_0$ colour at minimum light, and thus can be used to measure reddening. We used Blanco's (1992) improved calibration to estimate $E(B-V)$ for each RRL from its minimum-light $B-V$ colour and an assumed value of $\Delta S = 8.7$ (Harris 1996). Values ranged from 0.21 to 0.36 mag, with a mean of 0.28 and a standard deviation of 0.033 mag. This value compares favourably with that of Schlegel et al. (1998, 0.26 mag), and is somewhat larger that obtained by von Braun & Mateo (2001, 0.19 mag).

We corrected the magnitude and colour of each RRL using the $E(B-V)$ value derived for it. The dereddened $\langle V \rangle$ values averaged 13.905 mag, with a standard deviation of 0.054 mag. The scatter is typical of RRL in low-reddening clusters at the same abundance, suggesting that we have removed most or all of the scatter induced by differential reddening. When combined with an assumed absolute magnitude of $M_V(RR) = 0.56 \pm 0.12$ (Chaboyer 1998), we obtain a distance to NGC 3201 of 4.67 ± 0.25 kpc.

We produced a preliminary dereddened CMD of NGC 3201 as follows: for each non-variable star, we found the nearest RRL. If it lay within 30 arcmin, we adopted the RRL's reddening for that star and computed its dereddened magnitude and colour. The principal sequences of the resulting CMD are considerably tighter than the observed CMD, suggesting that this technique removes much of the effect of differential reddening. An improved correction will result when the remaining 35 RRL are included.

In conclusion, we have produced high quality B, V, I photometry for the brighter stars in NGC 3201, along with well-populated light curves for the cluster's RRL. Mean magnitudes and colours from the RRL light curves were used to obtain a mean dereddened apparent magnitude for the RRL in the cluster. When a definitive distance is available for NGC 3201 (e.g., via space-based astrometry), the data presented herein will be crucial in determining $M_V(RR)$ for this cluster.

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