A DEEP LUMINOSITY FUNCTION FOR 47 TUCANAE

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CCD photometry in B and V reaching B(lim) ≃ 25 has been employed to obtain the luminosity function and color-magnitude diagram for the main sequence of 47 Tuc. For $5<M_V<10$ we find that its LF is essentially flat ($\Delta \log n/\Delta m \sim 0$). The CMD is successfully matched by isochrones with [Fe/H] = -0.5 and t ≃ 15 x 10^9y.

In October 1983 at CTIO, we obtained CCD exposures in B and V for a series of fields in and near the prototypical "metal-rich" globular cluster 47 Tucanae (NGC 104 = CC021-723). Two fields on the west side of the cluster field (at r ≃ 19 arc min, or about 40% of the tidal radius), observed on consecutive nights, have been used to construct the color-magnitude diagram shown in Figure 1. Each pair of CCD frames is based on (5x800 sec) exposures in B and (10x500 sec) in V. Photometric calibration of the CMD was achieved by direct tie-in to fundamental E-region UBV standards and is believed to be systematically correct to ± 0.01 in V and B-V. All the final CCD photometry and reduction was completed with the Stetson DAOPHOT program, which employs automatic star finding, empirical PSF definition, and profile fitting.

Field-star contamination is remarkably low for V<21. Fainter than that, the contribution of the "background" SMC halo becomes a dominant feature (lower left of CMD). To derive a preliminary luminosity function for the 47 Tuc main sequence, we have simply assumed all stars falling within ≃2σ of the main sequence ridge line in the CM diagram to be cluster members. The resulting differential LF is shown in Figure 2. Note this preliminary LF has not been sufficiently corrected for field stars in the same color range as the cluster main sequence; taking these into account would slightly lower the points (for V > 22 particularly) and make the overall LF even flatter than it appears here.

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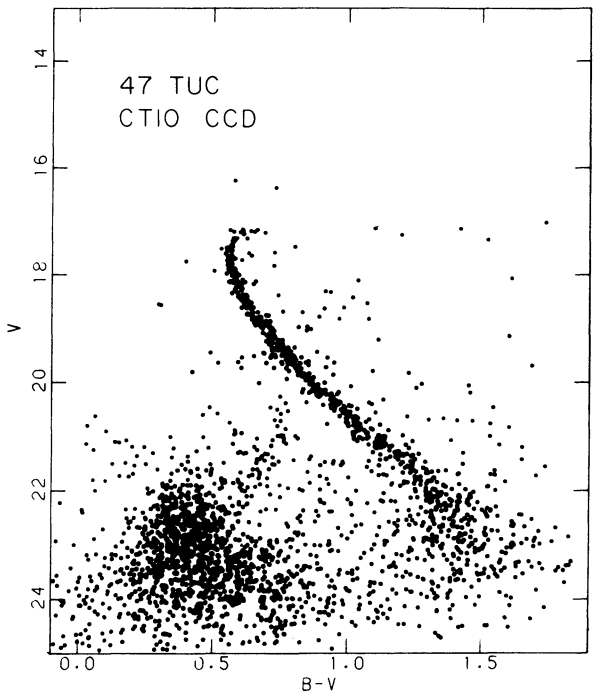

Figure 1. Color-magnitude diagram from CCD photometry of two 3' x 5' fields in 47 Tuc, obtained with the PF/CCD system at the CTIO 4-meter telescope.

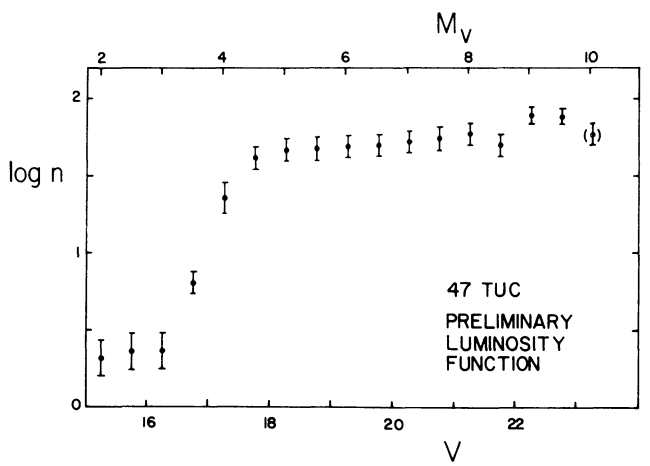

Figure 2. Differential luminosity function for the 47 Tuc main sequence, derived from Fig. 1 as described in the text. Here n is the number of stars per half-magnitude interval. The portion of the LF for $V \leq 17$ was obtained from Hesser and Hartwick (1977), appropriately scaled to match the upper main sequence. The absolute magnitude scale at top assumes $(m - M)_V = 13.2$.

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We are currently measuring two additional CCD "background" fields taken just outside the cluster tidal radius. These will eventually allow the construction of an improved LF in which point-by-point field star subtraction has been made and incompleteness at faint levels has been specifically estimated. However, we believe completeness to be essentially 100% for B<23 because of the rigorous automatic star-finding and image subtraction features in the DAOPHOT program. For B>24, completeness drops severely.

Da Costa (1982) used a series of V photographic plates to obtain the LF for 47 Tuc to V(lim) $\simeq$ 22.5. We find our results agree substantially with his for V < 20, but deviate significantly as we go further down the main sequence (our LF is flatter). If the Da Costa LF is correct (scaling it to match ours for V < 20) we should expect to see $\simeq$1350 main sequence stars brighter than V = 22.5 in our frames. In fact, we find $\simeq$570 such stars, i.e. a factor 2.4 fewer.

The CM diagram itself provides a precise definition of almost 6 magnitudes of the cluster main sequence. Note particularly the absence of any obvious binary-star sequence sitting above the ZAMS, or of any blue stragglers. We have carried out a preliminary fit of the diagram to Vanden Berg's (1984) most recently calculated isochrones. After a reddening correction of $E(\underline{B}-\underline{V}) = 0.04$, these models produce an excellent match to the observed main sequence for $(m-M)_V = 13.2$ (or $M_V(HB) = 0.9$) and an age of $(15 \pm 1) \times 10^9$y. The adopted model composition is Y = 0.2, Z = 0.006 ([Fe/H] = -0.5), with $\alpha = 1.6$.

Full discussions of this work are being prepared and will appear in the journal literature. For much practical help and stimulation we are indebted to Peter Stetson and Don Vanden Berg.

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