Globular-Cluster Color–Magnitude Diagrams with HST†

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This poster paper illustrates the color–magnitude diagrams discussed by Piotto et al. in the preceding paper. We present CMDs for 13 clusters; and we emphasize the discovery of additional blue horizontal branches in two metal-rich clusters, and the four-mode HB of NGC 2808.

1. Introduction

The factors that determine the morphology of the horizontal branch in globular clusters are still not well understood. Metal abundance plays an important role, with the most metal-rich clusters usually having the reddest HBs. However, a number of “second parameters,” such as age, have been proposed as explanations of the clusters that deviate from this rule.

Here we present preliminary results from a Hubble Space Telescope program that aims to explore connections between stellar evolution and cluster dynamics, and to investigate the CMD morphology of some clusters that are difficult to observe from the ground. The central regions of ten clusters were observed with the WFPC2 on HST. Some of the clusters chosen had a high central density and/or concentration; others had ultraviolet flux of unknown origin detected by IUE. We also include here three additional CMDs that we have derived from archival data originally taken by Yanny in another program.

We present two results: the discovery of additional blue horizontal branches in two metal-rich globular clusters, and the intriguing “clumpy” nature of the blue horizontal-branch tail of NGC 2808.

2. Blue horizontal branches in metal-rich clusters

An exciting result from this program has been the discovery of additional blue horizontal branches in two metal-rich clusters, NGC 6388 and NGC 6441. Both are extremely crowded from the ground, and their HBs have not been seen previously.

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Both clusters were also detected in the ultraviolet by IUE, and it was suggested that their UV brightness arose from blue HB stars. While a handful of blue HB stars have indeed been detected in metal-rich populations, blue populations as large as those discovered here have not previously been seen. (For discussion of these points, and references, see the preceding paper by Piotto et al.) What is puzzling, however, is that some other clusters with nearly the same metal abundance have no blue HB stars (see our CMDs of 47 Tuc and NGC 5927). It appears that another “second-parameter” problem may be at hand!

Figure 1. The upper two high-metal-abundance clusters have only a red stub of a horizontal branch, while the lower two have an additional blue portion.

3. The Long, Clumpy HB of NGC 2808

The horizontal branch of NGC 2808 has provided another fascinating result. Already known to be separated from the red stub, its blue end is now seen to extend many magnitudes fainter in V than previously known, down to V \( \simeq 21 \).

A CMD taken with an ultraviolet filter (F218W, \( \lambda_{\text{eff}} = 2189\AA \)) spreads out the HB tail in color, allowing better separation of stars of different envelope mass. A histogram
of this “blue vertical branch” shows that it is made up of at least two distinct groups, and possibly a third at its extreme blue end (in addition to the red stub that does not appear in the UV diagram). No mass-loss mechanism is known that could lead to such well-defined HB clumps.

![Figure 2. (left) The $(B, V)$ CMD of NGC 2808. (right) The (FUV, $B$) CMD of NGC 2808, with a graph above it showing the distribution of the stars in color. Note that the red-stub part of the HB is too weak in the FUV to appear in this diagram at all.](image)

4. Other clusters

The analysis of these data continues. Color–magnitude diagrams for our other clusters are shown in Figure 3; a number of interesting features in them are being investigated.
Figure 3. CMDs of eight more globular clusters.