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BLUE STRAGGLER STARS IN THE GLOBULAR CLUSTER M53

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ABSTRACT

The first large-format CCD color-magnitude diagram (CMD) in the B and V passbands is presented for the Galactic globular cluster M53 (NGC 5024). We have discovered 117 new blue straggler (BS) candidates in the field of M53. The analysis of bright BS stars (V<19.0) clearly shows a bimodal radial distribution, with a high frequency in the inner and outer regions. The distribution is similar to that found in M3, a globular cluster with similar central density and concentration.

Key Words : CCD photometry, globular clusters, blue straggler stars, M53

I. INTRODUCTION

M53 (NGC 5024=C1310+184) is a moderately compact metal-poor ($[Fe/H]$=−2.04; Zinn 1985) outer halo globular cluster that is rich in RR Lyraes. In general, it is analogous to M15 (NGC 7078), the classic Oosterhoff group II cluster, but its reddening is negligible ($E(B-V) = 0.0$; Zinn 1985) and the horizontal-branch (HB) morphology shows no hint for blue tail phenomenon (Cuffey 1965). M53 is of special interest as it may play an important role to clarify the debate surrounding the Sandage period-shift effect (Sandage 1982, 1990; Lee et al. 1990). Despite of its importance, M53 is one of the poorly studied Galactic globular clusters, which has motivated us to observe M53 with the large-format CCD camera. Here, we present the first result of our photometry on the blue straggler (BS) stars in M53.

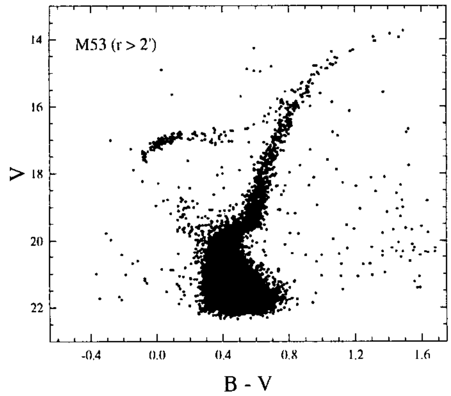

Fig. 1.— Color-magnitude diagrams for 4 radial zones in M53 based on the stars with $B-V$ errors less than 0.071 mag. Note that bright (V<19.0) BS stars are absent or rare in intermediate zones.

II. OBSERVATIONS AND REDUCTIONS

The observations were carried out during the nights 1995 March 30/31 and March 31/April 1 at Mauna Kea using the University of Hawaii 2.2 m telescope with the $f/10$ secondary and the Tek 2K CCD. 42 CCD frames per filter of four partially overlapping fields of the cluster center were taken. In total, these fields completely cover the cluster out to a radius of 8′ from the center. Only 6 BV pairs per field in the best seeing conditions (FWHM <1″.0) were used to obtain the photometry presented here. Reduction of all images was carried out using DAOPHOT II (Stetson 1987), with subsequent calibration using standard stars from Landolt (1992). The ADDSTAR task of DAOPHOT was used to estimate the completeness of our sample as a function of magnitude. This procrdure was repeated 16 times for each CCD field, both in the B and the V images.

III. BLUE STRAGGLERS

There are 120 BS candidates in our field of M53 including 3 BS stars already suggested by Fusi Pecci et al. (1992). We have inspected the individual images of stars in the BS region, i.e., with 18.0<V< 20.0 and -0.02<$B-V$<0.35, and those with substantial image contamination have been excluded. Figure 1 shows color-magnitude diagrams for four radial zones in M53 based on the stars with $B-V$ errors less than 0.071 mag, where the BS stars are plotted with larger symbols. Note that 28 bright (V<19.0) BS stars are apparently absent or rare in intermediate zones, while they are well populated both in the inner ($r < 1'$) and outer ($r > 4'$) zones.

The cumulative radial distributions presented in panel (a) of Figure 2 also suggest that the bright BS stars (dashed line) show a distinct dip in the distribution between $r = 1'$ and $r = 4'$, compared to the subgiant and red-giant stars (solid line) in the same magnitude range. Since these two samples should have approximately the same photometric accuracy and com-

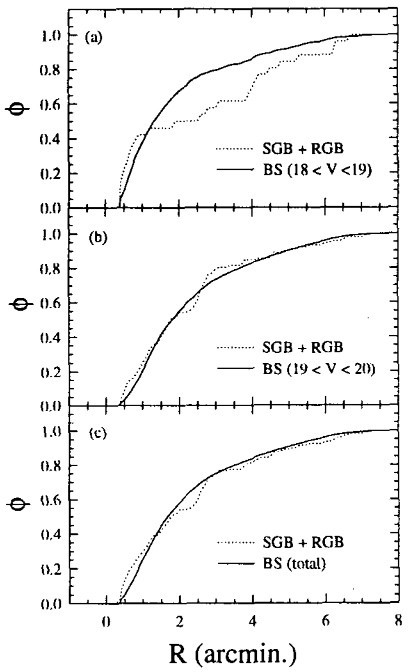

Fig. 2.— (a) Cumulative radial distributions for bright ($V < 19.0$) BS stars compared with sub-giant and red-giant stars in the same magnitude range. (b) Same as (a), but for faint ($V > 19.0$) BS stars compared with sub-giant and red-giant stars in the same magnitude range. (c) Same as (a) and (b), but for all stars in the BS region.

pleteness, our analysis suggests that the bright BS stars have a bimodal radial distribution. It is important to note that the similar distribution has been found in M3 (Ferraro et al. 1993), a globular cluster with similar central density ($log\rho$=3.86 vs. 3.53) and concentration ($c = logr_t/r_c$=1.85 vs. 1.60). This result may indicate that two distinct BS populations exist in M53 (see Ferraro et al. 1993; Stryker 1993; Bailyn & Pinsonneault 1995 and references therein), or alternatively that most BS stars in M53 were formed through binary collisions (Sigurdsson et al. 1994 and references therein). However, this behavior is not present in the faint ($V > 19.0$) BS stars, and consequently, the dip in the distribution is less clear when all stars in our BS region are considered (see Figure 2b,c). This difference between the "bright" and "faint" BS stars may also indicate that the origin for bright BS stars are different from that for faint BS stars (Bailyn & Pinsonneault 1995 and references therein). Additional observations of M53 core, especially with the HST, will undoubtedly help to clarify these problems further.

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