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ON THE BLUE STRAGGLER POPULATION OF THE GLOBULAR CLUSTER M55

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ABSTRACT

We have identified a large sample of 74 blue straggler stars (BSS) in the central region of the sparse, metal-poor globular cluster M55 (NGC 6809). Most of them form a relatively narrow, well-defined sequence extending from 0.6 mag below the main-sequence turnoff (MSTO) to about 2 mag brighter than the MSTO. Within the one core radius field that we observed, the BSS are more centrally concentrated than the MSTO and subgiant stars in the same magnitude range. About 15% of the BSS appear to form a secondary sequence ~ 0.75 mag above the main blue straggler sequence. Artificial star tests and the fact that these stars are strongly concentrated towards the cluster center suggest that at least some of them are binary BSS. Given the location and the small width of the blue straggler sequence we argue that the BSS in M55 are born with helium-enriched cores, but not envelopes. We conclude that the observed blue straggler sequence is the equivalent of a core helium-enriched main sequence (MS) where the BSS spend most of their life. Our observations are consistent with the assumption that the majority of the M55 blue stragglers are unmixed binary/collisional mergers or mass-transfer remnants. © *1997 American Astronomical Society.* [S0004-6256(97)00709-7]

1. INTRODUCTION

Blue straggler stars are usually defined as objects lying along the extension of the cluster MS, bluer and brighter than the MSTO. Most of the nearly 650 BSS observed in globular clusters so far have been found in sparse clusters (Ferraro *et al.* 1995), although recent high-resolution *HST* and ground-based observations (Ferraro *et al.* 1997; Yanny *et al.* 1994; Paresce 1993, and the references therein) show that BSS are found in abundance in more concentrated clusters as well. It is generally accepted that BSS have formed through a merger of two (or more) less-massive stars, although the nature and the details of the merger process are still far from certain. Recent reviews of the proposed merger mechanisms—direct stellar collisions, binary coalescence, mass transfer in a binary system or binary-binary collisions—can be found in Livio (1993), Stryker (1993), Leonard (1996), and Mateo (1996). The discovery of eclipsing variables among the BSS in NGC 5466 (Mateo *et al.* 1990) provided the first direct evidence that BSS are closely linked to binary stars. Since then more eclipsing binaries have been found among the BSS in both young and old clusters (see Mateo 1996 for a summary). It is clear now that blue stragglers are highly visible tracers of the binary population and its evolution, especially in low-concentration clusters such as M55, where a higher fraction of the primordial binaries is expected to have survived.

The first observations of BSS in M55 appear to be those of Sarajedini (1993), who reported the discovery of five blue stragglers. Zaggia *et al.* (1994) also noted the presence of BSS in the central region of M55, although they did not investigate their properties. In both cases either B, V or V, I filters were used, and as we argue later, these filter combinations make it difficult to separate the fainter BSS from the turnoff stars. As a result only the brightest and bluest of the BSS are discovered in such surveys.

2. OBSERVATIONS AND REDUCTIONS

The observations of the central region of M55 were obtained under excellent seeing conditions (FWHM $\approx 0\farcs7$) on 1992 August 24 at the Cassegrain focus of the 2.5-m du Pont Telescope of the Las Campanas Observatory. The detector used was the Tektronix 2 CCD, which contains 1024×1024 pixels at a scale of $0\farcs235$ per pixel, giving a field of view of $4' \times 4'$. A total of 30 frames through Johnson UBV and Cousins I filters were obtained: four in U ($2\times120+2\times300$ s), five in B (40 s each), 11 in V (10 s each), and ten in I (5 s each). For calibration purposes we also obtained 35 images of fields containing faint standard stars from the list of Landolt (1992).

The instrumental magnitudes were derived with the profile-fitting photometry program ALLFRAME (Stetson 1994) and transformed to the standard system using the photometric standards observed on the same night. Complete details on the reduction of the data will be presented in a forthcoming paper (Mandushev *et al.* 1997).

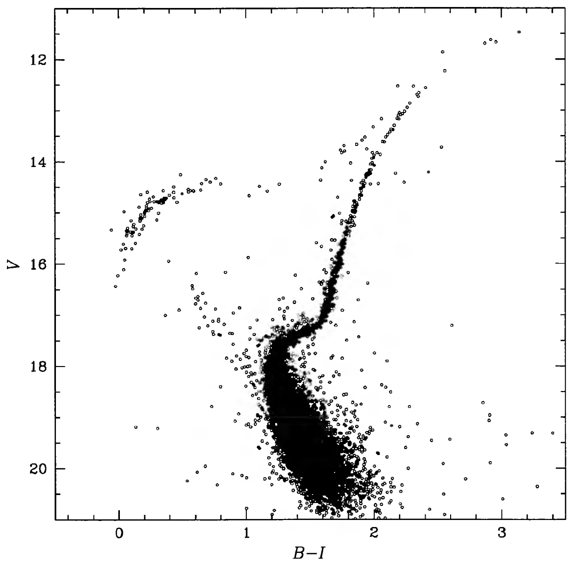

FIG. 1. The V, $B-I$ CMD for stars in the program field found on at least one V, B, and I frame.

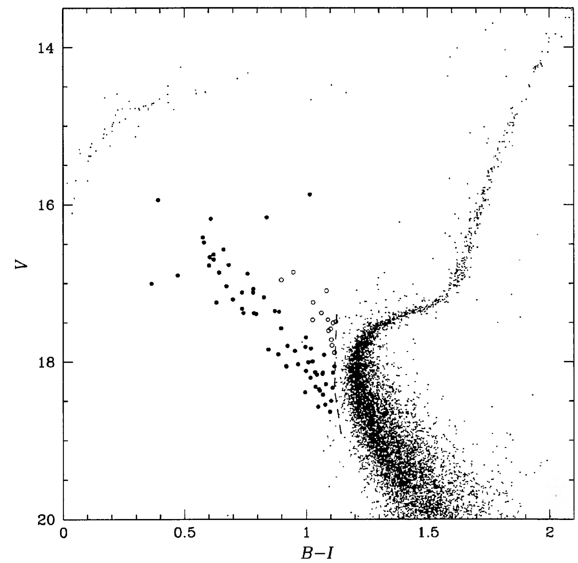

FIG. 2. The final BSS sample is shown by larger dots and empty circles. The dashed line marks the adopted separation between the BSS candidates and the turnoff stars.

3. THE BSS SAMPLE—DEFINITION AND COMPLETENESS

The selection of BSS candidates in the CMD is always somewhat subjective because of the continuous transition between the BSS region and the upper main sequence. This problem can be alleviated by using a color index that covers a wide wavelength range and hence provides a better color segregation between the BSS and the MSTO region. Among the various color indices that can be formed from our *UBVI* photometry, the $B-I$ color index provides much better temperature resolution than the $B-V$ and $V-I$ indices commonly used in BSS studies (see, e.g., Stetson 1993). The $U-I$ color index, though spanning an enormous wavelength baseline, produces an almost vertical MS in the BSS region and as such is not suitable for identifying faint BSS candidates. We have chosen, therefore, the V, $B-I$ CMD as our primary tool for studying the BSS in M55.

Figure 1 presents the CMD for nearly 9500 stars measured on at least one V, B, and I frame. The only objects not plotted here are those with photometric errors exceeding twice the median error for their magnitude. A prominent BSS sequence can be seen extending from below the MSTO to ~ 2 mag brighter than the turnoff. It is clear that the use of the $B-I$ color index, combined with the relatively precise photometry around the turnoff (the median $B-I$ error is below 0.02 mag at $V=18$) allowed us to trace BSS candidates more than 0.5 mag fainter than the MSTO. In order to put the BSS selection on a more objective basis, we obtained a fiducial MS for M55 and calculated the dispersion σ_{B-I} around the ridge line as a function of magnitude. We then compiled an initial list of BSS candidates consisting of all stars brighter than $V=18.65$ and with $B-I$ indices more than $3\sigma_{B-I}$ away from the ridge line. This approach ensured that most of the MS and turnoff stars scattered into the BSS domain by photometric errors were avoided when making up the BSS list.

The blue straggler region of the CMD is shown in more detail in Fig. 2, where the dashed line marks the adopted separation between the BSS candidates and the bulk of the turnoff stars. As seen there, we have left out the objects above the MSTO that could be possible blends of two turnoff stars. A few stars were removed from the initial list because they were too far to the red of the BSS region in the $B-V$ and $V-I$ CMDs. Also, two more BSS candidates were excluded as they did not converge in less than 200 iterations in ALLFRAME, indicating that their images were either nonstellar (e.g., faint blue galaxies) or severely blended (Stetson, private communication). At the end, a careful visual inspection of the remaining BSS candidates ensured that all of them looked ''normal'' and their photometry was not compromised by obvious cosmetic defects, diffraction spikes and the like. The final blue straggler sample, a total of 74 stars, is plotted in Fig. 2 by larger symbols (dots and circles) and listed in Table 1. A finder chart for the BSS is available from the authors upon request.

A natural question is how many of the stars identified here as blue stragglers are in fact field stars which only appear to be cluster BSS. One possible source of background contamination is the Galactic bulge since M55 is projected against its outer, low-density portion. However, we expect that most of the bulge stars would be located redward of the M55 MSTO (see Fig. 2 in Fahlman *et al.* 1996) and therefore would contribute little to the mostly blue BSS. On the other hand, the $V, V-I$ CMD of a comparison field north of M55 (Mandushev *et al.* 1996) shows no stars at all at the location of the BSS region. We conclude therefore that there is a negligible field star contamination of our BSS sample.

As seen in Fig. 2, most of the BSS in M55 form a surprisingly tight sequence extending from $V\approx 18.6$ to $V\approx 16$, and we shall refer to it as the blue straggler main sequence, or BSMS. Excluding the four brightest stars and the two stars to the blue of the BSMS, the BSS sample can be divided into two groups: the BSMS itself (solid dots) and the group of 14

TABLE 1. Photometry for the BSS in M55.

#	V	$B-V$	$U-B$	$V-I$	$B-I$	#	V	$B-V$	$U-B$	$V-I$	$B-I$
01	16.165	+0.312	−0.212	+0.526	+0.838	38	17.379	+0.426	−0.150	+0.636	+1.062
02	17.325	+0.257	−0.021	+0.480	+0.737	39	17.790	+0.494	−0.168	+0.612	+1.106
03	18.119	+0.371	−0.134	+0.628	+1.000	40	17.097	+0.428	−0.127	+0.656	+1.084
04	17.913	+0.445	−0.132	+0.628	+1.073	41	18.155	+0.452	−0.165	+0.614	+1.066
05	17.118	+0.350	−0.035	+0.432	+0.782	42	17.884	+0.461	−0.159	+0.656	+1.117
06	16.484	+0.244	+0.059	+0.336	+0.581	43	18.055	+0.419	−0.171	+0.498	+0.918
07	17.179	+0.361	−0.061	+0.466	+0.827	44	17.379	+0.353	+0.007	+0.390	+0.743
08	18.133	+0.404	−0.075	+0.633	+1.037	45	17.209	+0.332	−0.031	+0.367	+0.699
09	17.466	+0.461	−0.149	+0.628	+1.090	46	17.380	+0.280	−0.074	+0.505	+0.785
10	17.721	+0.450	−0.157	+0.654	+1.104	47	17.006	+0.129	+0.059	+0.235	+0.365
11	17.118	+0.210	+0.054	+0.527	+0.737	48	18.007	+0.436	−0.056	+0.574	+1.010
12	17.574	+0.381	−0.118	+0.517	+0.897	49	17.494	+0.459	−0.149	+0.663	+1.122
13	17.798	+0.415	−0.177	+0.509	+0.924	50	18.546	+0.410	−0.227	+0.668	+1.078
14	15.944	+0.133	−0.081	+0.259	+0.392	51	16.768	+0.289	+0.174	+0.393	+0.682
15	16.902	+0.197	+0.067	+0.275	+0.472	52	17.831	+0.409	−0.119	+0.610	+1.019
16	18.574	+0.453	−0.219	+0.596	+1.049	53	18.139	+0.474	−0.125	+0.636	+1.110
17	18.636	+0.431	−0.125	+0.667	+1.098	54	16.184	+0.225	+0.113	+0.384	+0.609
18	18.203	+0.383	−0.202	+0.634	+1.018	55	16.572	+0.287	+0.139	+0.374	+0.660
19	17.391	+0.301	−0.029	+0.495	+0.796	56	18.368	+0.456	−0.154	+0.601	+1.057
20	18.317	+0.437	−0.210	+0.601	+1.038	57	16.777	+0.233	+0.050	+0.368	+0.602
21	16.961	+0.358	+0.009	+0.541	+0.898	58	17.812	+0.438	−0.158	+0.560	+0.998
22	17.584	+0.455	−0.158	+0.646	+1.101	59	17.906	+0.338	−0.123	+0.548	+0.886
23	18.332	+0.431	−0.232	+0.677	+1.108	60	17.844	+0.386	−0.076	+0.459	+0.845
24	17.040	+0.229	+0.069	+0.443	+0.672	61	18.351	+0.461	−0.165	+0.592	+1.053
25	18.141	+0.445	−0.172	+0.624	+1.069	62	16.868	+0.271	+0.029	+0.371	+0.642
26	17.507	+0.498	−0.053	+0.612	+1.110	63	18.285	+0.464	−0.137	+0.617	+1.081
27	18.389	+0.341	−0.160	+0.656	+0.996	64	17.357	+0.378	−0.060	+0.493	+0.871
28	15.873	+0.457	−0.059	+0.559	+1.016	65	17.996	+0.431	−0.124	+0.596	+1.027
29	18.062	+0.383	−0.170	+0.537	+0.919	66	18.032	+0.419	−0.139	+0.549	+0.967
30	17.250	+0.255	+0.040	+0.376	+0.631	67	16.637	+0.276	+0.094	+0.344	+0.621
31	17.468	+0.432	−0.119	+0.595	+1.027	68	16.669	+0.260	+0.100	+0.344	+0.604
32	17.603	+0.451	−0.130	+0.641	+1.092	69	17.864	+0.396	−0.133	+0.558	+0.954
33	16.861	+0.383	−0.055	+0.565	+0.948	70	17.074	+0.326	−0.013	+0.457	+0.783
34	16.881	+0.286	−0.026	+0.473	+0.759	71	18.059	+0.457	−0.131	+0.660	+1.117
35	18.165	+0.449	−0.169	+0.595	+1.044	72	17.365	+0.343	+0.012	+0.547	+0.890
36	17.246	+0.416	−0.140	+0.613	+1.029	73	18.421	+0.477	−0.163	+0.592	+1.069
37	16.703	+0.262	+0.038	+0.359	+0.621	74	16.423	+0.244	+0.070	+0.331	+0.575

stars located ~ 0.75 mag above the BSMS (circles). The separation between the two groups is somewhat arbitrary at the red edge and it is possible that the few reddest BSS are in fact normal MSTO stars. These 14 stars (which we name supra-BSS) occupy a location suggesting that at least some of them may be binary BSS and we will discuss this proposition later. Another interesting feature of the BSMS is the apparent gap in the BSMS at $V \approx 17.5$. Our field covers only the central one core radius of M55 so this gap may not exist if a larger area were surveyed. We note that Sarajedini (1992) found a gap at the same location ($M_V \approx 3.6$) in the combined blue straggler luminosity function (LF) of NGC 5897 and NGC 6101.

The completeness of our blue straggler sample was estimated by generating 1500 artificial BSS in 10 separate experiments. The input V magnitudes were uniformly distributed between 15.85 and 18.70, and the colors of the artificial BSS were assumed to be represented by a straight line through the BSS region. From these experiments we estimated that the completeness f of the BSS sample is 0.97 ± 0.01 for BSS brighter than $V = 17.45$ and that it gradually drops down to $f \approx 0.94$ at $V = 17.65$ and $f \approx 0.77$ at $V = 18.05$, where most of the incompleteness is caused by the scatter of BSS into the MSTO region. These numbers indicate that our BSS sample is essentially complete for $V < 17.85$. Fainter than $V \approx 18.3$ the values of f become rather uncertain, as an increasing fraction of the added BSS is recovered to the red of the dashed line shown in Fig. 2. Thus, while we clearly see BSS fainter than the MSTO of M55, their completeness is difficult to estimate since we do not know what fraction of the faint BSS lies redward of the line used to select them in the CMD.

4. RADIAL DISTRIBUTION

Several studies of BSS in globular clusters have found them to be more centrally concentrated than the subgiant branch (SGB) and red giant branch (RGB) stars of similar brightness, first in NGC 5466 (Nemec & Harris 1987) and subsequently in many other clusters (Stryker 1993). In Fig. 3 we compare the cumulative radial distributions for three groups of stars in our field: 50 stars from the BSMS, 1901 MSTO, SGB and RGB stars, and the 14 stars which we provisionally named supra-BSS. For this comparison we used only stars with $V < 18.25$ since the fainter BSS are not as complete as the turnoff stars of the same brightness. A

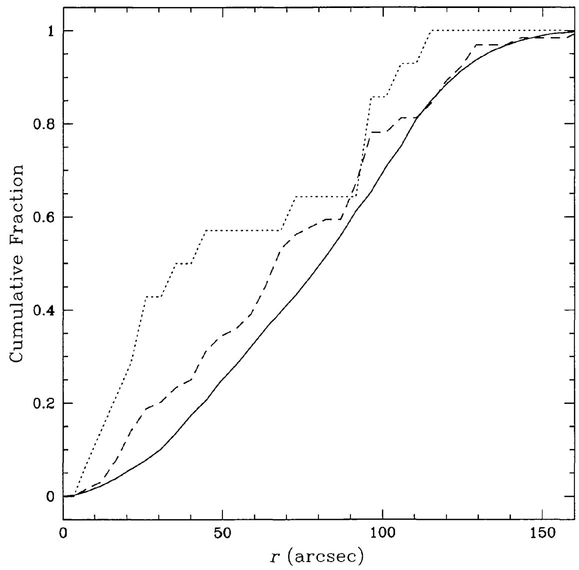

FIG. 3. The cumulative radial distributions for the total BSS sample (dashed line), the SGB and RGB stars in the same magnitude range as the BSS (solid line), and the supra-BSS (dotted line).

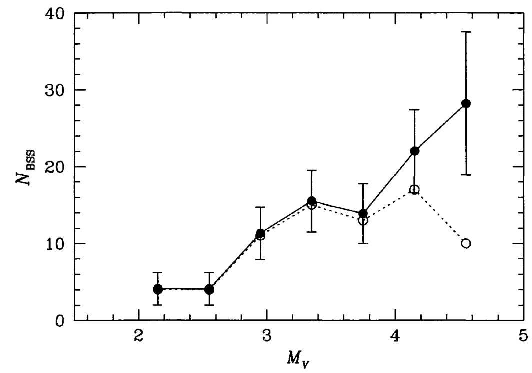

FIG. 4. The blue straggler LF in the central region of M55. Open circles show the raw counts, and filled circles show the counts corrected for incompleteness.

one-sided, two-sample Kolmogorov-Smirnov test applied to the cumulative distributions indicated that the 64 BSS in the whole sample are more centrally concentrated than the SGB stars at the 93% significance level, a result that is similar to the probabilities obtained in other studies. The difference in the radial distribution implies that the BSS in M55 are more massive than the $\sim 0.75\mathscr{M}_\odot$ subgiants and MSTO stars, as would be expected if they were formed by the merger of two less massive stars. What is also interesting is that the 14 supra-BSS are even more centrally concentrated, at the 92% level compared to the "main-sequence" BSS (the solid dots in Fig. 2), and at the 98% level compared to the SGB stars. As discussed in the next section, this property is consistent with the suggestion that at least some of those 14 stars are binary BSS.

5. A CASE FOR BINARY BSS IN M55

There is now overwhelming evidence that the BSS are closely linked to binary stars, either primordial or formed during stellar collisions (Livio 1993; Leonard 1996; Mateo 1996, and the references therein). About 40 binary BSS have been found so far in both open and globular clusters (Mateo 1996) and undoubtedly the numbers will grow. In globular clusters the evidence for binary BSS comes in the form of eclipsing variables but none have been found in M55 to date. Unfortunately, our longest series of frames (in V and I) span only about ten minutes each and therefore are not useful for searching for variable BSS. There are some indirect signs, however, that binary BSS are present in M55. The 14 stars marked by circles in Fig. 2 are located about 0.75 mag above the BSMS, as would be expected for objects comprised of two BSMS stars with roughly equal masses. It is unlikely that these are optical blends between either two BSS of similar colors or a "main-sequence" blue straggler and a SGB or MSTO star. While such blends do occur, the CMD of the recovered artificial BSS shows that (a) too few BSS (by an order of magnitude) are scattered by such blends into the area occupied by the 14 supra-BSS and (b) the blends are continuously distributed, without a gap between the brighter ones and the BSMS. Two other possibilities are: these are either older, less-massive BSS which have evolved away from the MS, or they have lower envelope helium content compared with the rest of the BSS. In either case it is difficult to explain why the supra-BSS would be more centrally concentrated than the other BSS, as demonstrated in the preceding section. On the other hand, their location in the CMD and the radial distribution of these 14 stars are consistent with the hypothesis that some of them are (detached) binaries comprised of two BSS or a BSS and a MSTO star, similar to NJL 5 in ω Cen (Helt *et al.* 1993). Such systems could have formed in binary-binary collisions or by merger of the close pair in a hierarchical triple, as shown by Leonard & Fahlman (1991, hereafter referred to as LF91) and Leonard (1996).

6. LUMINOSITY FUNCTION, ORIGIN, AND EVOLUTIONARY STATUS

The differential luminosity function (LF) for the BSS in our field is shown in Fig. 4. The dip at $M_V \approx 3.7$ is caused by the gap in the BSS sequence and may not be real. As can be seen, below $M_V \approx 4$ the incompleteness becomes noticeable and the last point in the LF is particularly uncertain. Still, it is clear that our LF is very different from the combined blue straggler LFs for sparse clusters derived in Fusi Pecci *et al.* (1992) and Sarajedini (1993). Their LFs exhibit a sharp drop at $M_V \approx 3.2$ and show virtually no BSS fainter than $M_V \approx 4.2$. We explain this discrepancy by the fact that their BSS samples were generally selected from V, $B-V$ CMDs where the fainter, redder BSS are indistinguishable from the turnoff stars.

It is now almost universally accepted that BSS are formed through a merger of two less massive stars, either by mass transfer/coalescence in a binary system or by direct stellar collisions (Benz & Hills 1987; Mateo *et al.* 1990; LF91; Leonard 1996; Mateo 1996). Recent studies by Procter Sills *et al.* (1995), Lombardi *et al.* (1996), Rasio (1996), and Sandquist *et al.* (1997, hereafter referred to as SBH97) have

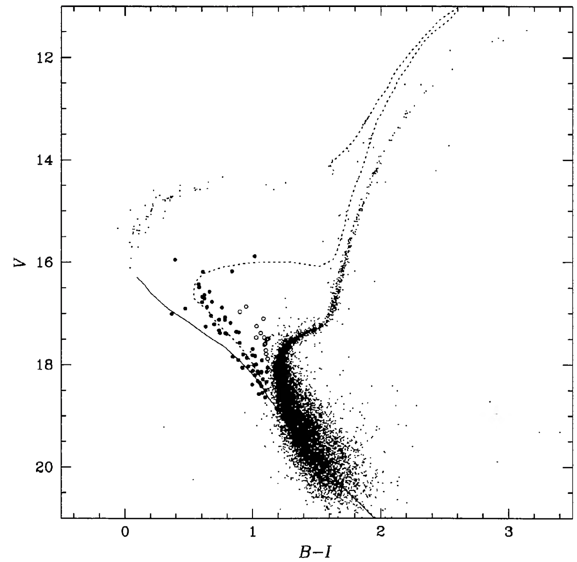

FIG. 5. The BSS distribution in the CMD compared to the ZAMS (solid line) and a 4 Gyr isochrone (dotted line) for single stars with the metallicity of M55. The theoretical sequences have been shifted by $(m-M)_V=13.90$ and $E_{B-I}=0.21$.

focused on the amount of mixing during the merger process and how it affects the merger products' lifetimes and location in the CMD. These newer simulations indicate that, contrary to what was assumed before, collisional remnants are not well mixed and have composition profiles similar to those of the parent stars; the models of SBH97 found that this is true for binary mergers as well. In addition, SBH97 followed the evolution of both mixed and unmixed mergers and suggested that because of their hydrogen-rich cores, fully mixed BSS should populate a relatively narrow locus along the ZAMS, as opposed to unmixed mergers which were predicted to spend the larger fraction of their lifetimes away from the ZAMS. Similar conclusions were reached also by Ouellette & Pritchet (1996).

In Fig. 5 we compare the distribution of the BSS in the CMD with the ZAMS and a 4 Gyr isochrone from Bertelli *et al.* (1994), whose models were calculated for $Z=0.0004$ and scaled solar abundances of the α-elements. This is a good approximation to an α-enhanced composition for M55 with $[\mathrm{Fe/H}]\approx-1.9$ (Zinn & West 1984; Minniti *et al.* 1993) and $[\alpha/\mathrm{Fe}]=0.3$, the latter being typical for many metal-poor globular clusters (Gratton & Ortolani 1989; Norris & Da Costa 1995). The ZAMS (solid line) and the 4 Gyr isochrone (dotted line) have been shifted by $(m-M)_V=13.90$ (Mandushev *et al.* 1996) and $E_{B-I}=0.21$. The adopted reddening is only approximate as it was obtained by a simple visual fit of the 16-Gyr isochrone from the same set of models to the MSTO of M55.

One can see that, unlike the BSS in many other clusters, the majority of the BSS in M55 form a relatively narrow sequence similar to the single-age population of ordinary cluster stars. This small width indicates that most BSS are in their longest-lived evolutionary stage, presumably core hydrogen burning. It is unlikely that these are completely mixed merger/collisional remnants, as the fully-mixed models of SBH97 spend much of their life close to the ZAMS and so we should see a concentration of BSS near the ZAMS, something that is clearly not observed for the brighter BSS in M55. These are found much higher than the ZAMS and resemble stars that have already evolved away from the MS. We conclude therefore that most of the BSS in M55 have helium-enriched cores (but not envelopes), similar to what unmixed merger remnants are predicted to be (SBH97). It follows then that the observed blue straggler sequence represents a core helium-enriched main sequence and that the newly-formed BSS should begin their life at its lower envelope. As can be seen in Fig. 5, for the less massive BSS this lower envelope approaches the single-star ZAMS, in agreement with the scenario outlined in SBH97: the progenitors of the low-mass BSS are low-mass single stars with little core helium enrichment and therefore we should find the former close to the ZAMS. We note, however, that the bright BSS observed in M55 are much higher above the ZAMS than predicted by SBH97 for the unmixed massive BSS. Adopting the 4-Gyr isochrone in Fig. 5 as the BSMS lower envelope, we find that it is about 0.5 mag brighter than the ZAMS at $(B-V)_0=0.18$, whereas the zero-age unmixed models of SBH97 are more luminous than the ZAMS by 0.25 mag at $(B-V)_0=0.04$ and by much less (~ 0.1 mag) at $(B-V)_0=0.18$. This discrepancy suggests that at a given mass, the M55 blue stragglers have a larger core helium content than predicted by the models of SBH97.

In Fig. 5 there are several bright BSS that are not on the BSMS. Two or three of them lie on or very close to the ZAMS and may well be fully-mixed mergers/collisional remnants. Since such BSS are expected to have long MS lifetimes, their small number indicates that complete mixing is a very rare event. The bright object located on the extension of the BSMS is probably a massive unmixed remnant, and three more BSS appear to be on the subgiant branch. Since the brightest stars on the BSMS are all evolved objects, they are not the most massive BSS. Their mass is probably close to the turnoff mass of the 4-Gyr isochrone ($\sim 1.1\mathscr{M}_\odot$), while the two presumably unmixed BSS near the ZAMS (at $V\approx 17.0$) would have masses of $\sim 1.3\mathscr{M}_\odot$. The fact that we do not see more massive objects also supports our conclusion that most BSS in M55 are unmixed merger/mass transfer remnants: such objects are formed with high core helium content and therefore evolve rapidly to the RGB.

As SBH97 found that little or no mixing occurs in either the collisonal or binary merger case, it is difficult to distinguish observationally between the two scenarios in the way suggested by Bailyn & Pinsonneault (1995). Given the low central density of M55, however, it is unlikely that the BSS in M55 are products of direct single-single stellar collisions of the type considered by Benz & Hills (1987). Without information on the numbers and the properties of binary BSS in M55 it is difficult to choose between the other possible formation scenarios—binary coalescence, mass transfer in a binary system (Mateo *et al.* 1990) or binary-binary collisions (LF91; Leonard & Linnell 1992). If any of these scenarios always results in a mixed remnant, however, it should be dismissed as a possible formation mechanism for most BSS in M55. Of course, it is also possible that more than one mechanism is at work in M55, as implied by the apparent presence of one or two fully-mixed BSS in the CMD. Several formation mechanisms have been proposed also for the BSS in M3 (Ferraro *et al.* 1993; Sigurdsson *et al.* 1994; Ferraro *et al.* 1997) and M67 (Leonard 1996).

The isochrone in Fig. 5 suggests that some of the stars seen to the blue of the RGB, as well as the few stars at the base of the asymptotic giant branch may be the descendants of massive BSS. This question has been discussed extensively by Fusi Pecci *et al.* (1992) and here we note only that this population of "blue" RGB objects may also include blends (or even binaries) in which one component is a red giant and the other one is a turnoff star or, less likely, a blue straggler.

7. SUMMARY AND CONCLUSIONS

We have identified and presented *UBVI* photometry for 74 blue stragglers in the sparse, metal-poor globular cluster M55. Our results indicate that the $B-I$ color index is the index of choice for BSS studies as it provides excellent temperature resolution around the MSTO and reduces the confusion between the faint BSS and the cluster turnoff stars. From artificial star tests we estimate that the BSS sample is essentially complete for $V<17.85$. Most of the incompleteness at fainter magnitudes is caused by the scatter of BSS into the turnoff region, where the completeness drops to ~ 0.8 at $V=18.05$. We find that as in many other clusters, the BSS in M55 are more concentrated towards the cluster center compared to the subgiants of similar brightness. We find also that the 14 BSS, which appear to form a secondary sequence ~ 0.75 mag brighter than the main BSS sequence, are even more centrally concentrated, at the 92% significance level compared to the normal BSS and at the 98% level compared to the SGB stars. This fact, combined with the results from artificial star tests that show low frequency of scatter to the supra-BSS region, suggest that at least some of these stars are binaries comprised of two BSS or a BSS and a MS star. Our observations are not suitable for search of variable stars in the BSS sample and more certain conclusions about the binary frequency among the M55 blue stragglers will be possible after the search for eclipsing binaries that we have planned is completed.

Most of our BSS form a tight sequence extending from 0.6 mag below the MSTO to about 2 mag brighter than the turnoff. Taking into account the small width of the BSS sequence and its location relative to the cluster ZAMS, we argue that the BSS in M55 are born with helium-enriched cores (but not envelopes), thus resembling stars that have already evolved away from the ZAMS. The degree of enrichment appears to increase with mass, as implied by the widening gap between the cluster ZAMS and the BSMS as one goes to higher luminosities. We conclude that the observed blue straggler sequence represents the equivalent of a core helium-enriched main sequence where the BSS spend most of their lives. Our observations agree qualitatively with the unmixed collisional/merger models of SBH97 and we conclude that the majority of the BSS in M55 are unmixed binary mergers or mass-transfer remnants. We cannot rule out collisional origin, especially from binary-binary collisions which could be common in sparse clusters. The absence of information on the frequency of binary BSS in M55 makes it difficult to choose a specific merger scenario, but the homogeneity of our BSS sample suggests that either a single formation mechanism is dominant in M55, or the variety of formation routes produce BSS with uniform properties.

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