Highlights of Astronomy, Volume 14
IAU XXVI General Assembly, 14-25 August 2006
Karel A. van der Hucht, ed.

doi:10.1017/S174392130701126X

Observations of blue straggler stars in globular clusters

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Abstract. Blue stragglers stars (BSS) define a sparsely populated sequence extending to higher luminosity than the turnoff point of normal main sequence stars in the color magnitude diagrams of stellar aggregates, thus mimicking a rejuvenated (more massive) stellar population. The nature of these stars has been a puzzle for many years and their formation mechanism is not completely understood, yet. Two mechanisms have been proposed to produce BSS: (*i*) the mass transfer in binary systems; and ((*ii*) the merger of two stars induced by stellar interactions. In this contribution we schematically report on the main properties of BSS in globular clusters (GCs) in the light of the most recent photometric and spectroscopic observations. These results, combined with dynamical simulations, indicate that both the proposed formation mechanisms play an important role in the production of BSS in GCs.

Keywords. stars: blue stragglers, stars: Population II, stars:evolution, techniques: photometric, techniques: spectroscopic

1. Introduction

Globular clusters (GCs) are important astrophysical laboratories for studying the evolution of single stars as well as binary systems. In particular, the evolution and the dynamical interactions of binary systems in high-density environment can generate objects that cannot be explained by standard stellar evolution (like X-ray binaries, millisecond pulsars, etc.). In this respect the most common by-product of binary evolution are the so-called blue straggler stars (BSS). They are commonly defined as those stars brighter and bluer (hotter) than the main sequence (MS) turnoff (TO) stars. BSS lie along an extrapolation of the MS, and thus mimic a rejuvenated stellar population. First discovered by Sandage (1953) in M 3, BSS are more massive than the normal MS stars, thus indicating that some process which increases the initial mass of single stars must be at work. Such effects could be related either to mass transfer (MT) between binary companions, the coalescence of a binary system or the merger of two single or binary stars driven by stellar collisions. Thus, BSS represent the link between classical stellar evolution and dynamical processes. The realization that BSS are the ideal diagnostic tool for a quantitative evaluation of the dynamical effects inside star clusters has led to a remarkable burst of searches and systematic studies, using UV (see Ferraro *et al.* 2003), optical broad-band photometry (see Piotto *et al.* 2004) and high-resolution spectroscopy (Ferraro *et al.* 2006), that provided a number of interesting results:

2. The radial distribution of BSS

In at least five GCs (namely M 3, 47 Tuc, NGC 6752, M 55 and M 5), the radial distribution of the BSS specific frequency has been found to be bimodal: highly peaked in the cluster center, rapidly decreasing at intermediate radii (the so-called zone of avoidance) and rising again outward. Though the number of the surveyed clusters is still low, these discoveries suggest that this *could be the 'natural' radial distribution of BSS*. Moreover, first results from dynamical simulations (Mapelli *et al.* 2004) indicate that the position of a given BSS in the GC may represent a strong dynamical clue on its formation mechanism: if it is located outside the zone of avoidance, the BSS almost certainly results from MT in primordial binaries (PBs), whereas the BSS found close to the cluster core have most likely a collisional origin.

3. Specific frequency and cluster mass

Piotto *et al.* (2004) noted an anticorrelation between BSS specific frequency and the cluster absolute magnitude (mass). Based on these results, Davies *et al.* (2004) suggested that BSS in low mass systems ($M_V > -8$) arise mostly from MT in PB. In more massive systems stellar interactions produce mergers of the primordial binaries early in the cluster history, hence BSS resulting from these mergers are already evolved away. Then, the BSS that we are currently observing in the cores of the most massive systems ($M_V < -9$) are mostly collisional BSS. However detailed cluster-to-cluster comparison has shown that the emerging scenario is much more complex than this, since the dynamical history of each cluster apparently plays a significant role in determining the origin and radial distribution BSS content (Ferraro *et al.* 2003).

4. The chemical signature of the BSS formation process

Indication about the origin of the BSS can be obtained from high resolution spectroscopy. Indeed the chemical signature of the MT-BSS formation process has been recently detected in 47 Tuc (Ferraro *et al.* 2006), where a sub-population of BSS showing a significant depletion of carbon and oxygen with respect to the dominant population has been discovered. This evidence suggest the presence of CNO burning products on the BSS surface coming from a deeply peeled parent star, as expected in the case of MT process. This is the first detection of a chemical signature clearly pointing to a specific BSS formation process in a GC. The C-O depleted BSS seem to share the same radial distribution of 'normal' BSS. A few of them have been identified as W UMa systems (i.e., shrinking binary systems which are losing orbital momentum because of magnetic braking and that would finally merge into a single star). Most of the observed BSS are found to be slow rotators, with velocities compatible with those measured in unperturbed TO stars. However, it is interesting to note that the few fast rotator BSS, the C-O depleted BSS and the W UMa stars are all located in a narrow strip in the low-luminosity region of the BSS distribution, peraphs suggesting that they are the most recently born. The cooler, older BSS rotate more slowly and have 'normal' C-O abundances. This evidence would suggest that, as the rotation starts to slow, mixing might be induced diluiting the surface C-O under-abundance, pushing C-O back toward 'normalcy'. The acquisition of similar sets of data in clusters with different structural parameters and/or in different regions of the same cluster will provide an unprecedented tool to finally address the BSS formation processes and their complex interplay with the dynamical evolution of the cluster.

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