Dynamical Characterization of Blue Stragglers Stars in Galactic Globular Clusters

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Abstract

High-resolution spectra with the IMACS/Baade spectrograph of more than ~100 Blue Straggler Star (BSS) candidates has been obtained to study their dynamical characteristics and detailed chemical composition in three nearby Galactic Globular Clusters (GCs). Such data have never been taken for most of these BSS targets and in combination with precise astrometric and accurate photometric HST/ACS data available for all our targets, our complementary spectroscopy could help characterize the chemo-dynamical properties of the BSS populations in these benchmark Galactic GCs. Our work attempts to correlate dynamical and chemical properties to obtain the full chemo-dynamical information that will constrain BSS formation scenarios (binary vs. merger). In the recent literature, two formation mechanisms have gained most acceptance and are currently lively debated: (i) BSSs form in collision-induced stellar mergers, or (ii) BSSs are rejuvenated stars forming by mass transfer in a binary system. Both of these scenarios are believed to be actively at work and their predominance being a function of the local environment. Collision-induced BSSs are expected to form in the high density parts of GCs, while mass-transfer BSSs are thought to form in loose outskirts of GCs. In the mass-transfer scenario, the resulting BSS is believed to conserve most of the angular momentum from the binary system, therefore becoming a fast rotator (Vsini > 50 km/s). On the other hand, the collision-induced BSS formation is believed to lose most of the initial angular momentum through accretion disk braking/locking.

Sample and Observations

- Neigh, Sills and Knigge (2011) propose a photometric selection criteria for different populations in a GC. We use this to find BS candidates in NGC3201, NGC6218 and NGC5139.
- The spectroscopic target selection has been performed on photometric catalogs from the HST/ACS Galactic GC Survey by Sarajedini et al. (2007) for the inner cores, and from ESO archive's WFI photometry for the outskirts.
- We observed the night of March 21st 2012 under fair seeing conditions (1''). We used IMACS multi-slit mode with a configuration R~10000, ~0.2 Å/pix, ~3600-5300 Å.

Sample Demographics

- NGC 3201: 42 BSS candidates
- NGC 6218: 34 BSS candidates
- NGC 5139: 61 BSS candidates

Total Sample : 137 BSS candidates.

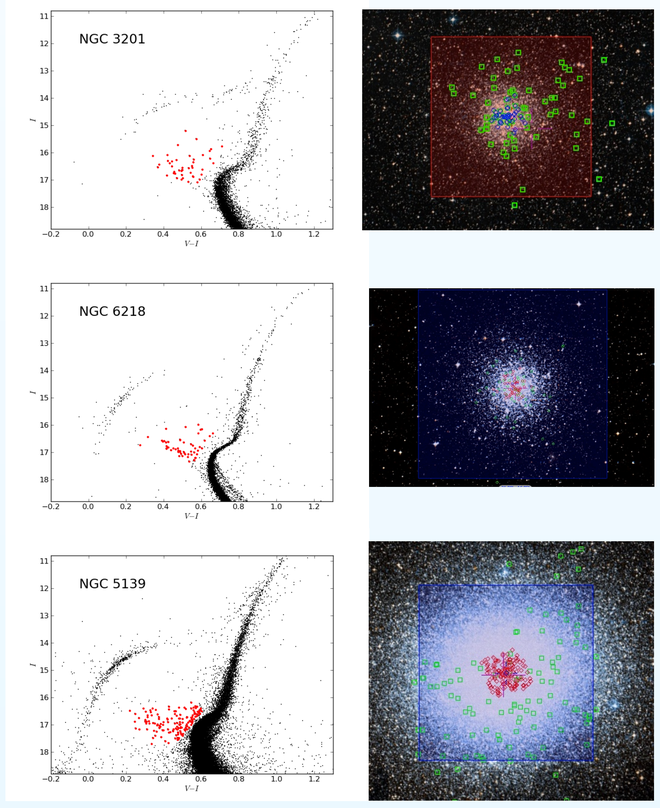


FIGURE 1: The color magnitude diagrams of the inner cores of our three targets. The photometry comes from the catalog of Sarajedini et al. (2007). The BSs candidates selected from the photometric criteria are the points in red. In the right we see the spacial distribution of the BSs candidates throughout the clusters. Different colors in the picture represent the two samples: ACS data and WFI data, the former being the inner ones and the latter being the outer ones. Also displayed is the FoV of IMACS (~15'x15').

Cluster Membership

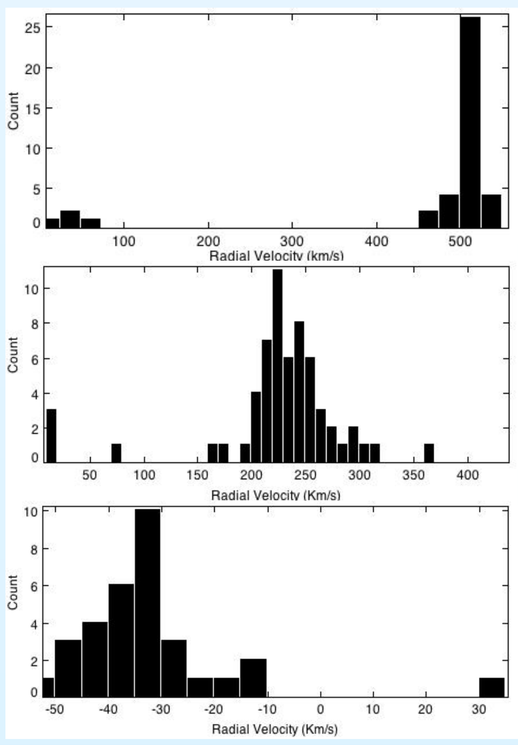


FIGURE 2: The heliocentric radial velocities of the BSS candidates. Top: BSS candidates in NGC 3201. This cluster has a measured velocity of 494 Km/s (Harris 1996). Middle: BSS candidates in NGC 5139. This cluster has a measured velocity of 232 Km/s (Harris 1996). Bottom: BSS candidates in NGC 6218. This cluster has a measured velocity of -41 Km/s (Harris 1996). From our measurements we presume that most of out BSS candidates are members of their GC. Some outliers are observed and these could be signs of the already known very dynamic nature of the BSS.

How fast do they rotate?

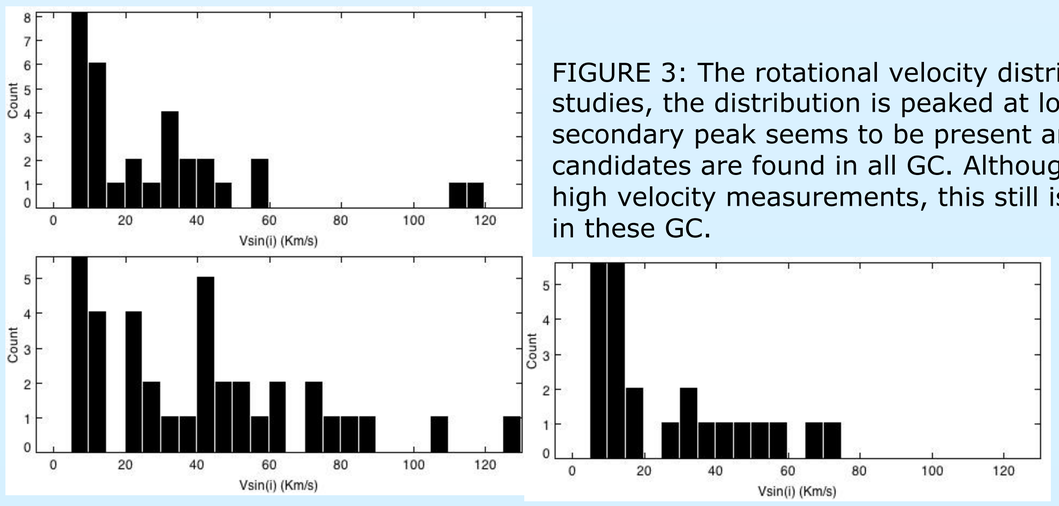


FIGURE 3: The rotational velocity distributions of the BSS candidates. Similar to previous studies, the distribution is peaked at low rotating velocities (~10 Km/s) but a significant secondary peak seems to be present around ~40 Km/s. Fast rotating (>50 Km/s) BSS candidates are found in all GC. Although we need to be cautious with the accuracy of such high velocity measurements, this still is a strong hint for fast rotators BSS being present in these GC.

Top : NGC 3201.
Low Left: NGC 5139.
Low Right: NGC 6218.
Note the dynamically active case in NGC 5139.

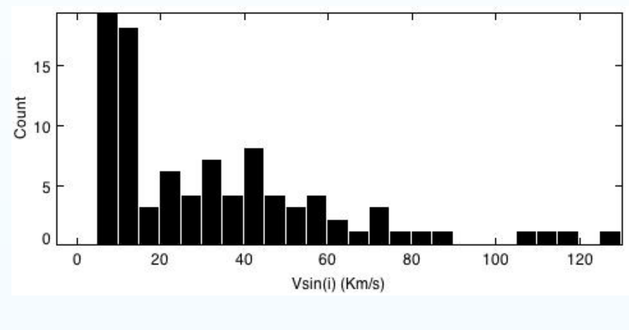


FIGURE 4: The rotational velocity distributions of all our BSS candidates. This seem to confirm the apparent secondary peak at Vsin(i) ~ 40 Km/s.

Looking for a dynamical correlation

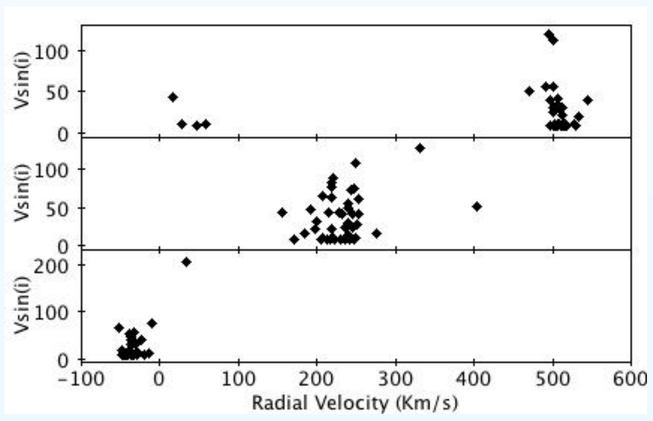


FIGURE 5: The radial velocity of the BSS candidates versus their rotational velocity. Top: NGC 3201, Middle: NGC 5139, Bottom: NGC 6218. There is confirmation of most BSS with odds radial velocity being also fast rotators. This could be a hint of extreme dynamical conditions related to the BSS formation.

Vsin(i) versus CMD position

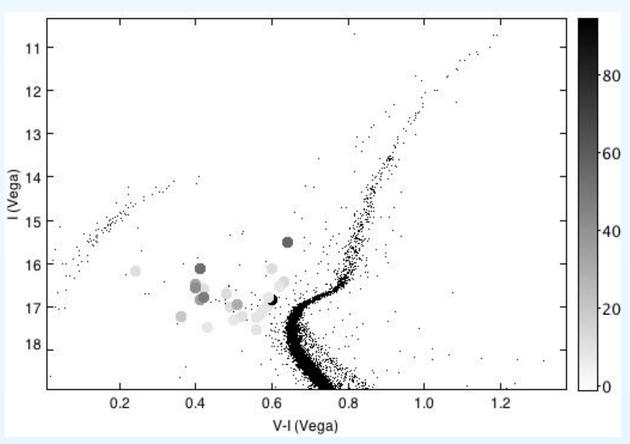
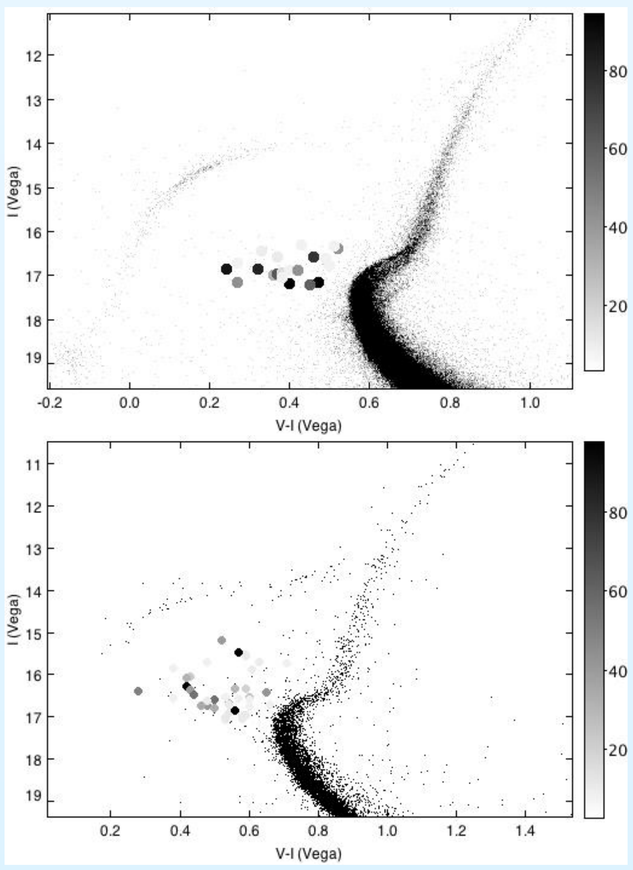


FIGURE 7: Top: NGC 3201, Middle: NGC 5139, Bottom: NGC 6218. The bid dots represent the BSS candidates and their blackness represent their rotating velocity. The bar in the right is the legend for Vsin(i) values in Km/s. The most notable feature of these plots is the tendency of fast rotators to be located at the bluer side of the "BSS main sequence". Further analysis could relate this to BSS formation scenarios.



References

- Harris, W.E. 1996, AJ, 112, 1487
- Sarajedini et al. 2007, AJ, 133, 1658
- Leigh, Knigge, Sills 2011, MNRAS, 415, 3771