Blue straggler stars beyond the Milky Way
On the origin of blue straggler stars in Magellanic Cloud clusters

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Blue straggler stars are “baby” stars in old stellar systems.

Formation Channels:
Direct stellar collisions
Binary evolution
(mass transfer, merger)
A binary star fraction of 76 per cent and unusual orbit parameters for the blue stragglers of NGC 188

Robert D. Mathieu & Aaron M. Geller
A binary origin for ‘blue stragglers’ in globular clusters

Christian Knigge, Nathan Leigh & Alison Sills

Nature 457, 288–290 (15 January 2009)
Letter

Two distinct sequences of blue straggler stars in the globular cluster M 30


Received: 30 June 2009
Accepted: 21 October 2009
An Unexpected Detection of Bifurcated Blue Straggler Sequences in the Young Globular Cluster

Chengyuan Li, Licai Deng, Richard...  
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BLUE STRAGGLERS

Clumsy encounters or graceful mergers?

Alison Sills

Nature Astronomy 2, 362–363 (2018) | Download Citation

Observations of two sequences of blue stragglers in a young, sparse star cluster in the Large Magellanic Cloud re-opens the debate about the dominant formation mechanism of these anomalous stars.
Why Magellanic Cloud clusters?

Advantage:

• They cover a wide age range.
• They suffer minor effect of extinction.
• They are not so dense like Galactic globular clusters.

Disadvantage:

• Field contamination is poorly constrained.
• Crowding due to large distance.

Instrument:

HST, ACS/WFC & UVIS/WFC3

• Filtered in B, V & I band (central wavelength from 435nm to 814nm).
• Resolution of ~80 mas in optical, equal to ~0.02 pc at LMC.
Surface Density Profile

\[ \rho(r) = \rho_0 \left(1 + \frac{r^2}{a^2}\right)^{-\gamma/2} + \rho_{\text{bkg}}, \]

\[ r_c = a\left(\frac{2}{\gamma} - 1\right)^{1/2}. \]

Model parameters:
- Age (log\(t/\text{yr}\)),
- Metallicity (Z),
- Extinction (Av),
- Distance modulus ((m-M)₀).

Structure parameters:
- Core size (r_c)
- Half-light radius (r_{hl})

Dynamical parameters:
- Cluster Mass (M)
- Cluster Core Mass (M_C)
- Central mass density (\(\rho_0\))
- Core velocity dispersion (\(\sigma_0\))
A sub-linear relationship between the number of core BSSs and the core mass is revealed.
$n_{\text{bss,c}} \text{ vs. } \gamma$

$\Gamma = \left( \frac{\rho_o}{M_\odot \text{pc}^{-3}} \right)^2 \left( \frac{r_c}{\text{pc}} \right)^3 \left( \frac{v_{c,\sigma}}{\text{km s}^{-1}} \right)^{-1}$

$\gamma \equiv \Gamma/(M/10^5 M_\odot)$
Why sub-linear?

\[ N_{\text{bss}} \propto f_{\text{bin}} M_{\text{core}} \]

However, \( f_{\text{bin,core}} \propto M_{\text{core}}^{-0.37 \pm 0.06} \)

Milone et al. 2012

Leigh et al. 2013 based on the datasets from Milone et al. 2012
Why sub-linear?

$N_{bss} \propto f_{bin} M_{core}$

Dynamical implication of low mass-ratio binaries in young massive clusters
--- new insights into the secondary main sequence in cluster NGC 1850

Most young massive clusters in the Large Magellanic Cloud have bimodal or extended main sequences. It is suggested that the secondary main sequence stars are decelerated stars which hide a binary component. In this work, we examine this scenario through looking at the radial segregation of blue main sequence stars in cluster NGC 1850. We find that the blue main sequence stars are less segregated than normal stars and are anti-correlated to high mass-ratio binaries in radial. We suggest that this is because the blue main sequence stars are low mass-ratio binaries, for which the dynamical disruption is efficient in the cluster central region.

**QUESTION:**
What is the radial behaviour of these secondary main sequence stars (blue dots) compared to genuine high mass-ratio binaries (pink dots)? If these secondary main-sequence stars are single stars, they should have the same radial profile like normal main-sequence stars (green dots).

1. Blue main sequence stars are low mass-ratio binaries. Most of them have been disrupted through three-body interactions in the cluster central region.
2. The radial anti-correlation between blue main sequence stars and high mass-ratio binaries may indicate that the dynamical mass-exchange process among these binaries is ongoing.
\[ N_{\text{bss},c} \text{ vs. } \gamma \]

\[ n = C + a\gamma^b. \text{Pooley & Hut (2006)} \]

Simulation data derived from Chatterjee et al. (2013)

Binary disruption
Take-home message

The main formation channel for blue straggler stars in Magellanic Cloud clusters, is **binary evolution**.

Future work:
1. binary fractions in MC clusters.
2. mass segregation of blue straggler stars.
3. origin of bifurcation of blue straggler stars in young globular clusters
Blue straggler stars beyond the Milky Way. II. A binary origin for blue straggler stars in Magellanic Cloud clusters

Weijia Sun, Chengyuan Li, Richard de Grijs, Licai Deng

(Submitted on 13 Jun 2018)

We have analyzed populations of blue straggler stars (BSSs) in 24 Magellanic Cloud star clusters using multi-passband Hubble Space Telescope images. We compiled a homogeneous BSS database, containing both traditional and evolved BSSs. We uncovered a sub-linear correlation between the number of BSSs in the cluster cores and the clusters' core masses, characterized by a power-law index of $0.51 \pm 0.07$. For low stellar collision rates, the mass-normalized number of BSSs depends only weakly (or perhaps not at all) on the collision rate, implying that the binary-driven BSS formation channel dominates. Comparison with simulations suggests that stellar collisions contribute less than 20\% to the total number of BSSs formed. Further tests, including analysis of the BSS specific frequencies and their population numbers at larger cluster radii, suggest that binary interactions may be their main formation channel, hinting at an anti-correlation between a cluster's binary fraction and its core mass.

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