Blue Straggler Stars in Open Clusters using Gaia: Macro Properties and Formation Pathways

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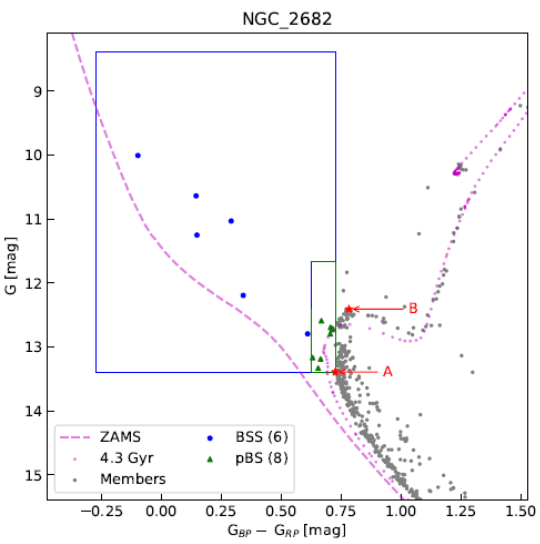


Fig.1 Selection of BSSs (and probable BSS viz. pBS) from cluster CMD.

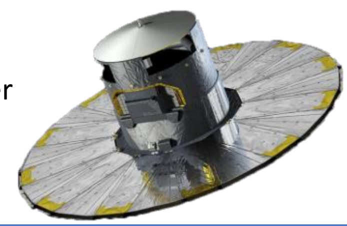
Blue straggler stars (BSSs): Cluster members which are bluer and brighter than the main sequence turnoff (MSTO) stars due to some type of material gain.

Selection of blue stragglers

1. Reliable cluster membership (Gaia collaboration et al 2018, Cantat-Gaudin et al. 2018, 2020)
2. Cluster sample: Older than 300 Myr
3. Identification of cluster MSTO
4. Selection of members bluer and brighter than cluster MSTO

Data

We used membership cluster parameters derived from Gaia DR2 data to select and characterise the BSSs.



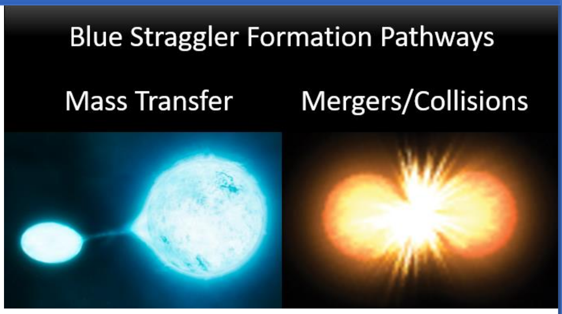


Fig.2 Primary formation pathways of BSSs.

Formation of BSSs

1. Binary mass transfer (McCrea 1964)
2. Mergers and collisions in dense environments (Hills et al. 1976)
3. Merger of inner binary in hierarchical triple system (Naoz et al. 2014)

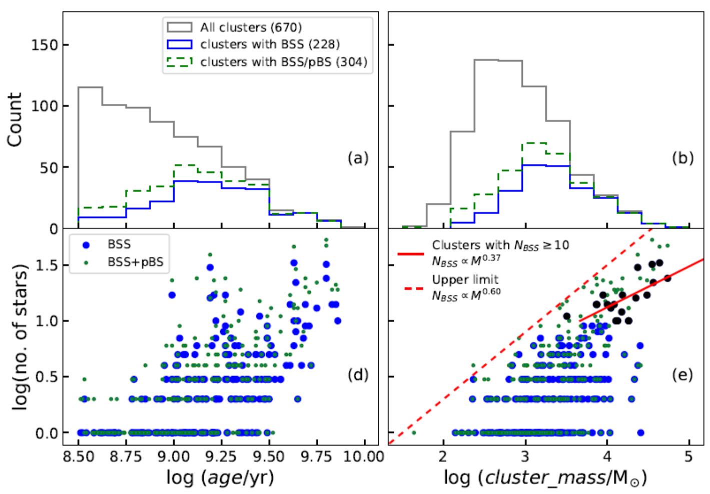


Fig.3 Histograms of (a) cluster age and (b) cluster mass with and without BSS. Variation of number of BSSs per cluster with (d) cluster age and (e) cluster mass.

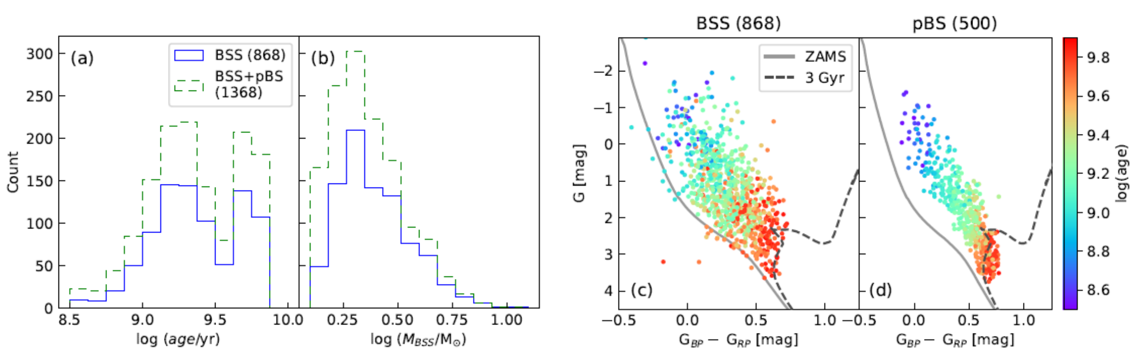


Fig.4 Histograms of the (a) age and (b) mass of the BSSs. Absolute CMDs of (c) BSSs and (d) pBS colored according to the parent cluster age.

- For 670 clusters with age > 300 Myr
  - 228 clusters have 868 BSS
  - 208 clusters have 500 pBS
  - 366 clusters don't have BSS/pBS
- 90% of the BSSs are in clusters older than 1 Gyr.
- BSS mass ranges from 1.3—11 $M_\odot$ With peak at ~2 $M_\odot$.

Fractional Mass excess

$$M_e = \frac{M_{BSS} - M_{MSTO}}{M_{MSTO}} \sim \text{Equivalent to mass transfer efficiency}$$

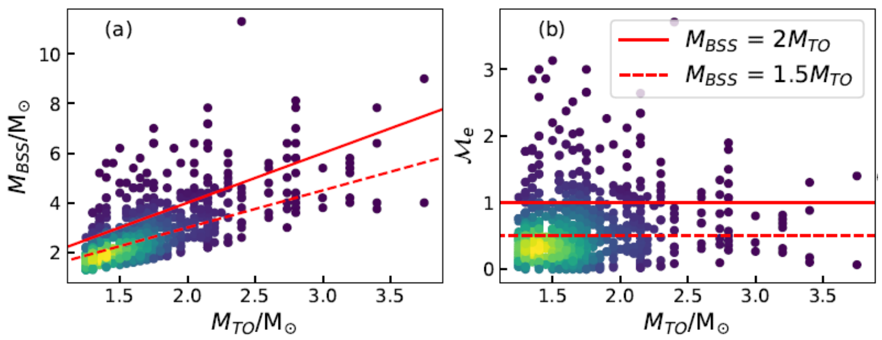


Fig.5 (a) Variation of BSS mass with respect to MSTO mass. (b) Variation of M_e with respect to MSTO mass

$M_e < 0.5$: possible through mass transfer

$0.5 < M_e < 1$: Likely mergers

$M_e > 1$: More than 2 MSTO stars

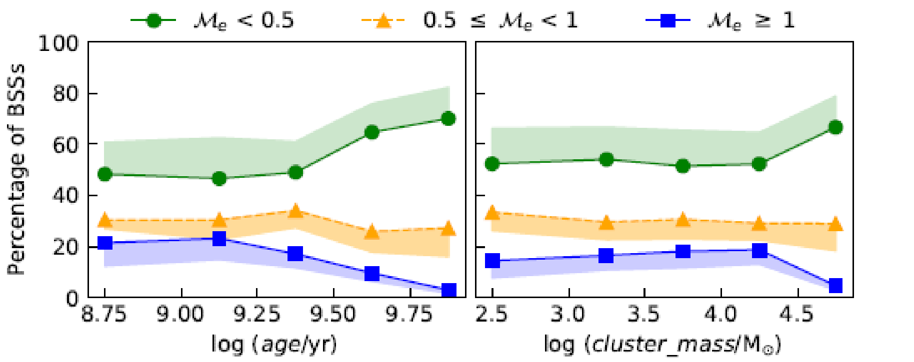


Fig.6 Change in the fraction of BSSs in different M_e classes with (a) cluster age and (b) cluster mass

Conclusions

- 34% clusters older than 300 Myr have BSSs
- Almost all old and massive cluster have BSSs
- There is no relation between number of BSSs and metallicity, cluster radius, Galactocentric distance
- Formation pathways:
  >54% through binary mass transfer
  ~30% through mergers
  <16% through multiple interactions
- Older clusters favor binary mass transfer pathway while diminishing multiple interaction pathway
- Number of BSS has power-law relation with cluster mass (and number of stars) similar to globular clusters: $N_{BSS} \propto M_{cluster}^{0.37 \pm 0.10}$
- The maximum number of BSSs per cluster is $N_{BSS,max} \propto M_{cluster}^{0.6}$
- In general, BSSs in relaxed clusters are segregated

References

Cantat-Gaudin et al., 2018, A&A, 618, A93
Cantat-Gaudin et al., 2020, A&A, 640, A1
Gaia Collaboration et al., 2018, A&A, 616, A1
Hills et al., 1976 Astrophy. Lett., 17, 87
Jadhav et al., 2021, MNRAS, 507, 1699
McCrea, 1964, MNRAS, 128, 147
Naoz et al., 2014, ApJ, 793, 37

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