A Simple Analytic Model For Blue Straggler Formation in Globular Clusters

Nathan Leigh[1]

With: Alison Sills[1] & Christian Knigge[2]

[1]McMaster University, [2]University of Southampton

February 26, 2009

The Beginning…

The Question: **What is the dominant blue straggler (BS) formation mechanism operating in globular clusters (GCs), if there is one at all?**

- GC cores are thought to host a large number of direct stellar collisions on a timescale that is short compared to the average BS lifetime (i.e. $\tau_{coll} << \tau_{BS}$)

The Data: 56 GCs taken from Piotto et al.'s 2002 HST database

- Looked for trends between BS frequency ($F_{BS} = N_{BS}/N_{RGB/HB}$) and cluster parameters

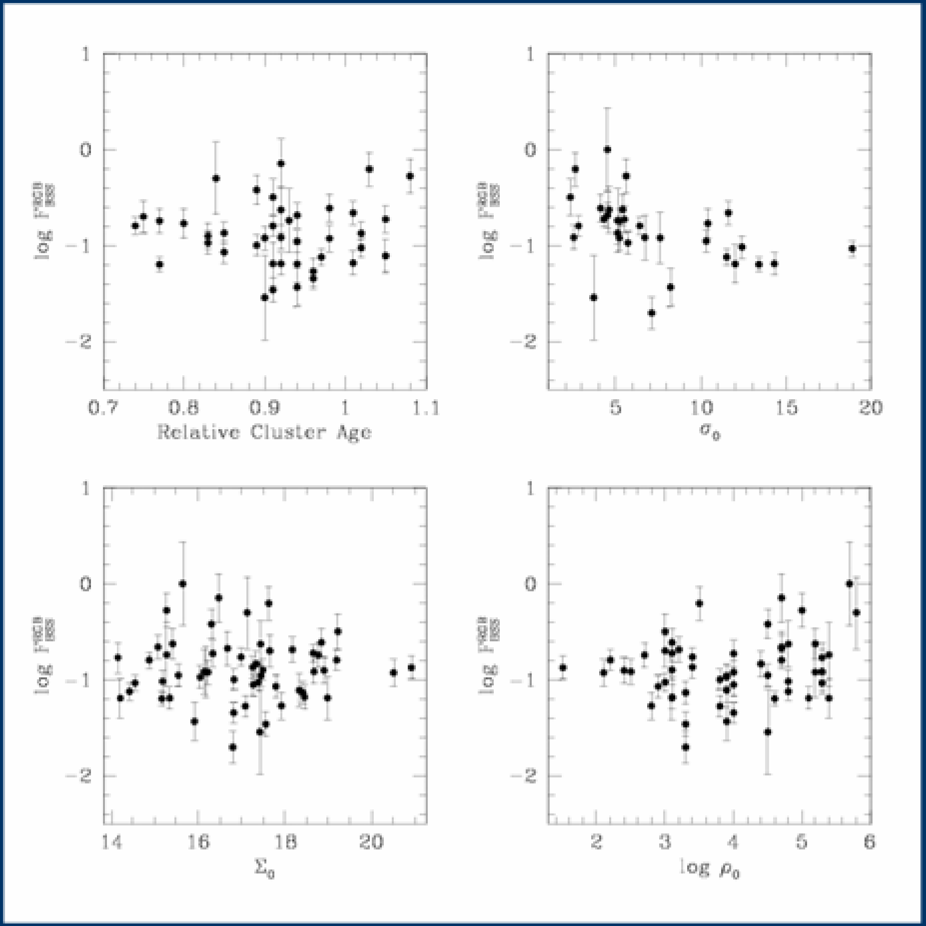

Figure 1: Plots of core BS frequency versus the logarithm of the central density (bottom right), the central surface brightness (bottom left), the relative cluster age (top left) and the central velocity dispersion (top right) (taken from Figure 3 of Leigh, Sills & Knigge. 2007, ApJ, 661, 210).

NO TRENDS! BUT…

A New Angle of Attack…

- Adopting the simplest prescriptions for the two competing BS formation mechanisms:

  1) If most BSs are formed via 1+1 collisions, their number in a given GC core should scale as $N_{BS,coll} \sim \tau_{BS}/\tau_{coll}$

  2) If most BSs are descended from binary stars, their number in a given GC core should scale as $N_{BS,bin} \sim f_{bin}M_{core}$

N.B. These represent the simplest versions of their corresponding models and ignore intermediate channels

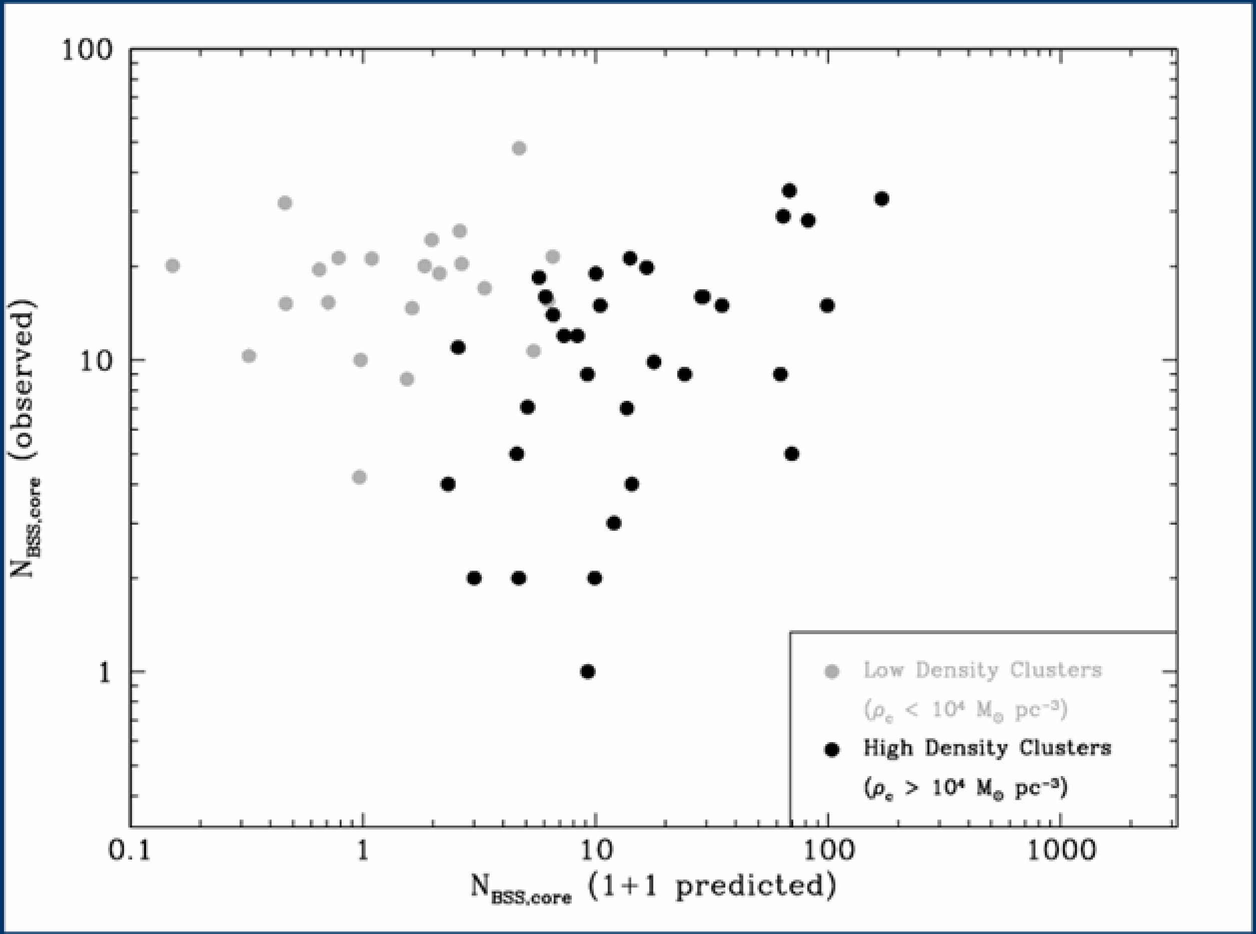

Figure 2: The observed numbers of core blue stragglers versus the numbers expected from single-single collisions. There is no correlation between observed and predicted numbers across the full sample (Spearman's rank test yields ρ = -0.03). For the subset of dense clusters, however, a correlation does exist (ρ = 0.52) (taken from Figure 1 of Knigge, Leigh & Sills. 2009, Nature, 457, 288).

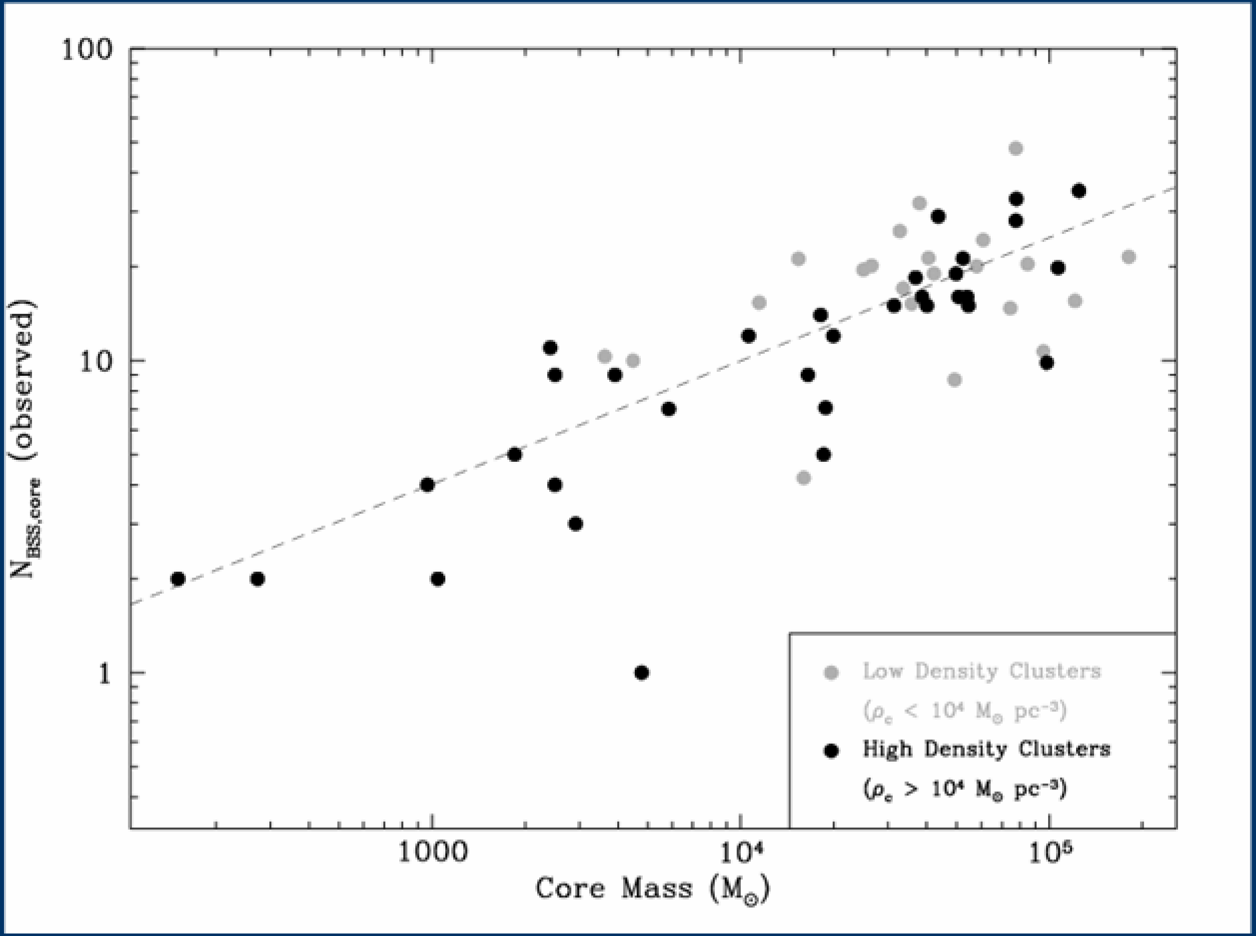

Figure 3: The observed numbers of core blue stragglers versus the estimated core masses. BS numbers and core masses are strongly correlated (Spearman's rank test yields ($\rho = 0.71$), as expected if BSs are descended from binary systems. The correlation with core mass also holds for the subset of dense clusters ($\rho = 0.84$) and in both cases is stronger than that with collision rate. The best-fitting power law is $N_{BS} \sim M_c^{0.38 +/- 0.04}$, as shown by the dashed line (taken from Figure 2 of Knigge, Leigh & Sills. 2009, Nature, 457, 288).

Issues to Address…

1) What role do 1+2 and 2+2 encounters play?
2) How does mass segregation factor in?

- In order to detangle the competing effects of dynamical encounters, binary evolution and mass segregation, we have created an analytic formalism to gauge their relative importance in BS production….

The Model

Given some initial population of BSs (N_0), their number in a given GC core can be expressed at any subsequent time using the generalized formula:

$$N_{BS,core} \sim N_0 + N_{coll} + N_{mt} + N_{in} - N_{out} - N_{ea}$$

A Few Simplifying Assumptions…

- Single stellar mass $\Rightarrow$ m_{BS} and τ_{BS} are the same for all BSs
- Only concerned with the last τ_{BS} years of cluster evolution
- $\rho(r)$ and $\sigma(r)$ from King distribution function
- Shell model for the cluster

The Breakdown…

- $N_{coll} = f_{1+1}N_{1+1} + f_{1+2}N_{1+2} + f_{2+2}N_{2+2}$
- $N_{mt} = f_{mt}f_{bin}N_{core}/2$
- $N_{in} \rightarrow$ calculate N_{coll} and N_{mt} in each radial shell for which $t_{df} < \tau_{BS}$
- $N_{out} \rightarrow$ assume a kick velocity for BSs formed in 1+2 and 2+2 collisions

Results

…in progress…

References

Knigge, C., Leigh, N., & Sills, A. 2009, Nature, 457, 288

Leigh, N., Sills, A., & Knigge, C. 2007, ApJ, 661, 210

Piotto, G., King I. R., Djorgorvski, S. G., Sosin, C., Zoccali, M., Saviane, I., De Angeli, F., Riello, M., Recio-Blanco, A., Rich, R. M., Meylan, G., & Renzini, A. 2002, A&A, 391, 945