Simulating the Recovery Rate of Eclipsing Binaries in Star Clusters with LSST

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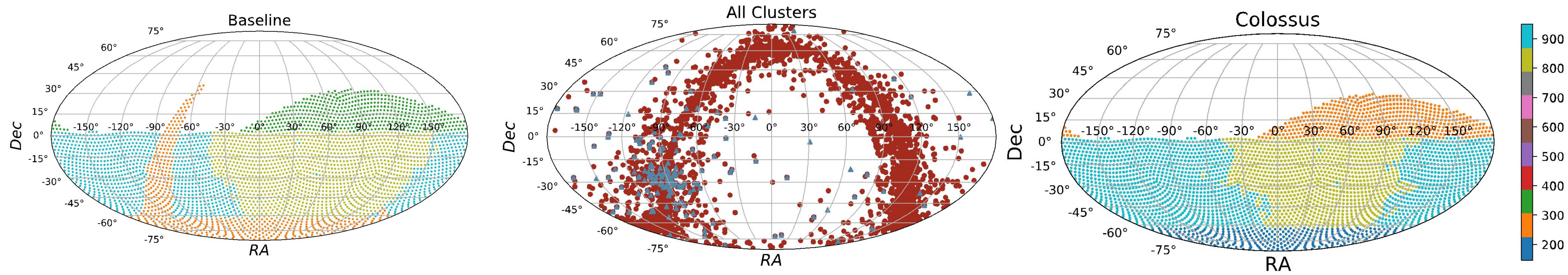
Abstract

We present a study of the period-recovery capability of the Large Synoptic Survey Telescope (*LSST*) for eclipsing binary stars in star clusters. Unlike binaries in the galactic field, dynamical encounters within the dense environment of a star cluster can modify the orbital parameters of binaries stars by changing the periods and eccentricities and exchanging in different companions. Therefore, eclipsing binaries in star clusters may allow for insights into both the intrinsic properties of the binary's component stars, as well as the dynamical histories of the binary population. For our simulations, we use COSMIC [1] to generate and evolve populations of binaries specifically catered to each of the thousands of galactic open and globular clusters (e.g., matching the cluster ages, metallicities, periods at the hard-soft boundary, etc.). We generate light curves, in the LSST filters and expected cadence and accounting for the expected photometric precision of LSST, for each observable eclipsing binary, using the ellc [2] code. We then attempt to recover the orbital period for each observed binary through a Lomb-Scargle periodogram, using gatspy [3] software. We compare the baseline cadence proposed for LSST to a cadence that samples the galactic plane (where most open clusters reside) more evenly. In this poster, we present expected recovery statistics for eclipsing binary stars in the galactic open and globular star clusters for both of these proposed observing strategies.

Choosing an LSST Cadence

We simulate LSST viewing conditions with the Operations Simulator (OpSim) to generate observation dates and fields. The plot below demonstrates the observing pattern between the *baseline* and *colossus* OpSim observing strategies, as well as the on-sky location of sampled clusters.



Binary Population	Baseline (N_{bin})	Colossus (N_{bin})
All	~6 x 10^6	~6 x 10^6
Observable	5762	7132
Recovered	3315	3729

Fig 1. Mollweide projection plot of 157 globular and 1811 open clusters *Left*: observing fields with $N_{obs} > 0$ for the *baseline* observing strategy. *Center:* mollweide projection plot showing on-sky locations of globular (triangle) and open (circle) clusters surveyed. *Right*: observing fields with $N_{obs} > 0$ for the *colossus* observing strategy.

LSST will recover thousands of eclipsing binaries in Milky Way star clusters.

Population and Cluster Statistics

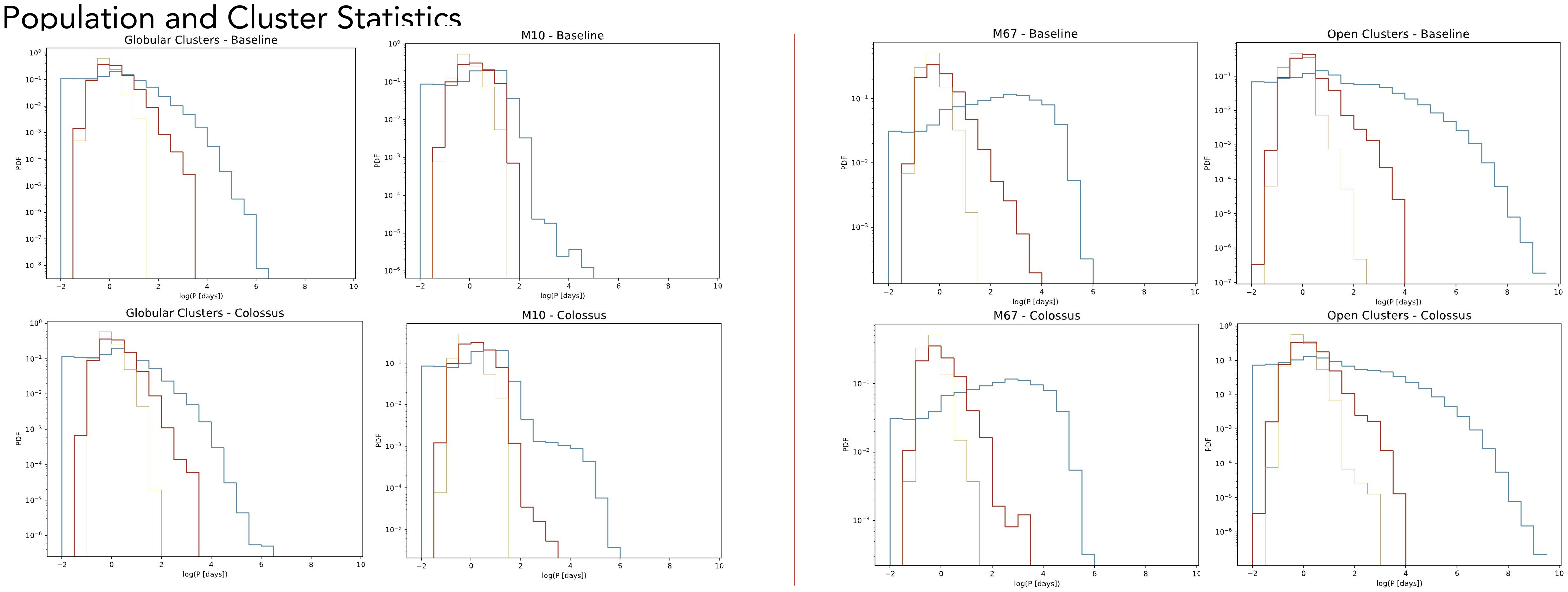


Fig 2. Binary population statistics for (in order from left to right): All 157 globular clusters surveyed, M10, M67, All 1811 open clusters surveyed. *Top row:* log-period (log-days) for *baseline* strategy, *Bottom row*: period recovery for *colossus*. The binary period distribution was cut at the hard-soft boundary for each cluster. Color indicates binary subpopulation: All Binaries, Observable Binaries, Recovered Binaries

Crowding

One consideration that must be taken into account with clusters is the effect of crowding sources in LSST's viewing field. We are currently adding this into our analysis to see how these effects would alter the period recovery rate for both LSST observing strategies. This is done with the 3rd light parameter in ellc's light curve software.

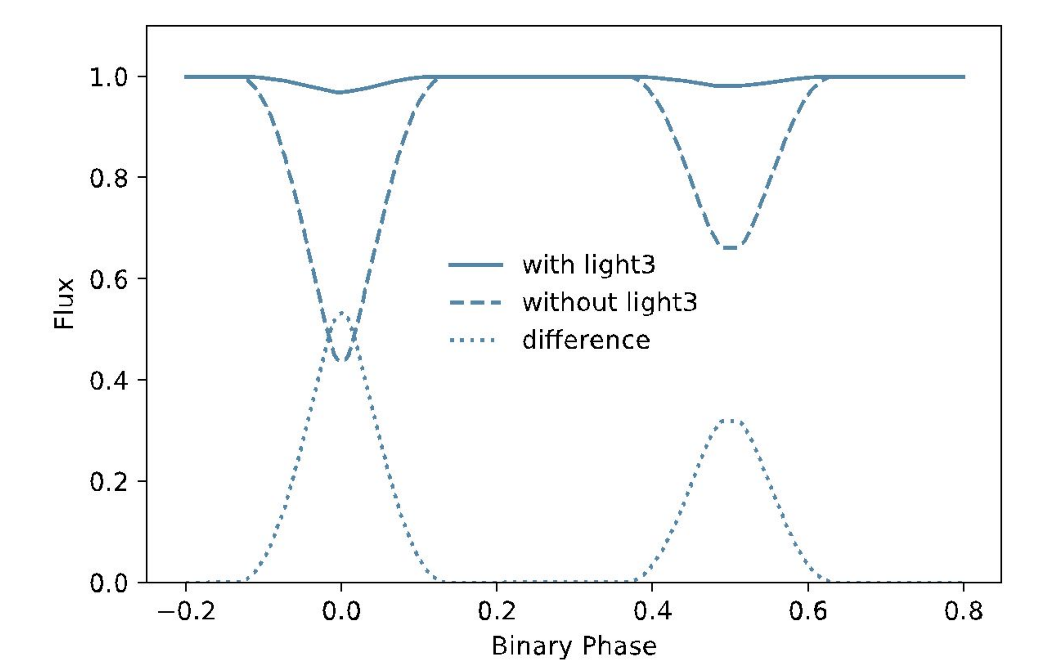
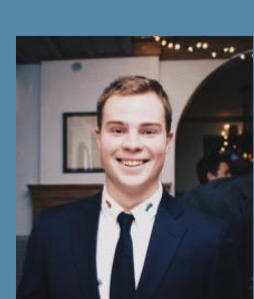


Fig 3. Light curves of a sampled binary with and without crowding light added. The difference between the two light curves plotted underneath

For a look at the code for this project,visit our GitHub at:



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- References
- [1] Breivik, K. 2018
- [2] Maxted, P.F.L. 2016
- [3] VanderPlas, J. T., & Ivezi´c, Zˇ. 2015
- Geller, A. M., & Leigh, N. W. C. 2015
- Kharchenko, N. V., Piskunov, A. E., Schilbach, E., Ro¨ser, S., & Scholz, R.-D. 2013
- 2Maxted, P.F.L. 2016
- Piskunov, A. E., Schilbach, E., Kharchenko, N. V., Ro¨ser, S., & Scholz, R.-D. 2008
- Polzin, A., Geller, A., Miller, A., & Breivik, K. 2019
- Prša, A., Pepper, J., & Stassun, K. G. 2011