The Effects of Binaries on Recovered Remnant Populations

1 Motivation and Rationale

Current, state-of-the-art equilibrium models typically assume that all stars are single and make no effort to include the dynamical effects of binary systems. The highest mass binary systems are of comparable mass to the heaviest white dwarfs and neutron stars and should also mass segregate at a similar rate. A large centrally concentrated population of binaries could very well occupy the same dynamical role as a population of heavy remnants and thus reduce the need for a large central population of black holes and neutron stars. By including the dynamical effects of binaries in our models we hope to recover more accurate remnant populations for present-day globular clusters.

Binary populations in globular clusters are, in general, not very well constrained. Even for clusters for which we have large photometric surveys or multi-epoch radial velocity measurements, we are often only able to observe binary systems with high mass ratios. This results in loose constraints on the total binary fraction and weak constraints on the mass ratio distribution above $q = 0.5$, with essentially no constraints on the mass ratio distribution for $q < 0.5$. There are a few options in the literature for likely mass ratio distributions, the one with the most observational motivation being a flat mass ratio distribution where all values of q between 0 and 1 are equally likely. Other options include random sampling from the IMF or adopting the observed mass fraction distribution from binaries in the solar neighbourhood. By adopting a mass ratio prescription and binary fraction we can generate a realistic population of binaries that is likely to mimic those found in present-day clusters.

2 Methodology

Because of the high densities and old ages of globular clusters, we can safely assume that all long period, loosely bound binaries have been ionized by the present day. This allows us to treat binary star systems as a single system for the purposes of our models, a binary system of two $0.5M_\odot$ stars should behave like a single star of $1M_\odot$. This means that in order to replicate the effects of binary stars in our models we can simply shift some of the stars in our binned mass function into bins of higher mass according to the properties of the chosen binary population.

When we fit these modified models to observations, we need to take special care when comparing them to the available stellar mass function data. The method used to collect the

mass function data is to assume all observed stars are single stars and to assign each star a mass based on its luminosity. This means that when we compare our models to the data we will need to convert the dynamical mass of the binaries into an "observed mass" which is related to the total luminosity of the binary system. These binary bins will then contribute to the single star bin which is closest to the "observed mass" of the binary bin for the purposes of computing mass function likelihoods.

3 Timelime

- Get the realistic binary populations working (November 5th)
  - Implement equal mass binaries. ✓
  - Implement flat q distribution. ✓
  - Truncate q distribution according to smallest possible value of q.
  - Tweak current implementation to better handle the lowest mas stars.
- Project Summary (Nov 1st) ✓
- Integrate models with binaries with GCFit (January 7th).
  - Re-bin models with binaries to reduce the runtime (November 19th)
  - Keep track of the overall binary populations within the rebinned models (Dec 3rd)
  - Use isochrones to get the apparent luminosity of the binary systems and use this to estimate the "observed mass" of the binary systems in order to re-scale the number density profiles for mass function likelihoods. (January 7th)
- Literature Review (Jan 31st)
- Toy models (Nov 19). We can run a few models with realistic binary populations and compare them to models without binaries. This will let us look at the effects of the binary systems without needing to fit models to real data.
- Fit models (Jan 28th). Once we've modified the mass function likelihood to work with binaries, we can fit our models with binaries to real observations of clusters and see how the model parameters and remant populations change with the inclusion of realistic binary populations.
- Progress Report (Feb 7th)
- Thesis Draft (March 18th)
- End date (April 4th)