Formation, evolution, and survival of massive star clusters
Proceedings IAU Symposium No. 316, 2015
C. Charbonnel & A. Nota, eds.

doi:10.1017/S174392131501042X

Binary Information from Open Clusters Using SEDS (BINOCS) Project: The Dynamical Evolution of the Binary Populations in Cluster Environments

Peter Frinchaboy[1] **and Benjamin Thompson**[1]

[1]Department of Physics & Astronomy, Texas Christian University,
2800 S. University Ave., Fort Worth, TX, USA 76129
email: p.frinchaboy@tcu.edu, b.a.thompson1@tcu.edu

Abstract. Studying the internal dynamics of stellar clusters is conducted primarily through N-Body simulations. One of the major inputs into N-Body simulations is the binary star frequency and mass distribution, which is currently constrained by relations derived from field binary stars. However to truly understand how clustered environments evolve, binary data from within star clusters is needed including masses. Detailed information on binaries masses, primary and secondary, in star clusters has been limited to date. The primary technique currently available has been radial velocity surveys that are limited in depth. Using previous two-band photometry-based studies that may cover different mass ranges produce potentially discrepant interpretations of the observed binary population. We introduce a new binary detection method, Binary INformation from Open Clusters Using SEDs (BINOCS) that covers the wide mass range needed to improve cluster N-body simulation inputs and comparisons. Using newly-observed multi-wavelength photometric catalogs (0.3 - 8 microns) of the key open clusters with a range of ages, we can show that the BINOCS method determines accurate binary component masses for unresolved cluster binaries through comparison to available RV-based studies. Using this method, we present results on the dynamical evolution of binaries from 0.4 - 2.5 solar masses within five prototypical clusters, spaning 30 Myr to 3.5 Gyr, and how the binary populations evolve as a function of mass.

Keywords. binaries: general, open clusters and associations: general, methods: miscellaneous

1. Introduction

Current cluster binary studies are carried out using one of two methods, two-band photometry, and time-baseline radial velocity studies, each of which experience issues which limit their effectiveness in answering the above science questions. However, to deeply understand the binary populations of open clusters, we have created a new method which can determine accurate masses for all members of a cluster within a reasonable amount of telescope time. This new binary detection method is nicknamed BINOCS: BINARY INFORMATION FROM OPEN CLUSTERS USING SEDS. By imaging a star using multiple filters across the spectrum (e.g., $UBVRIJHK_S$[3.6][4.5][5.8][8.0]), one should be able to "rebuild" *spectral energy distribution* (SED) of a star given its parameters: age, metallicity, mass. Similarly, a binary system could not be accurately modelled by a single SED curve, but instead by two SEDs added together. By matching stars to these models, mass can be determined, similar to how temperature could be determined in the idealized blackbody case. Since the star is a member of a cluster with known parameters, so age and metallicity are given. By matching stars to models of a library of synthetic single stars SEDs, mass can be determined. Isochrones often come in coarse mass grids. To overcome

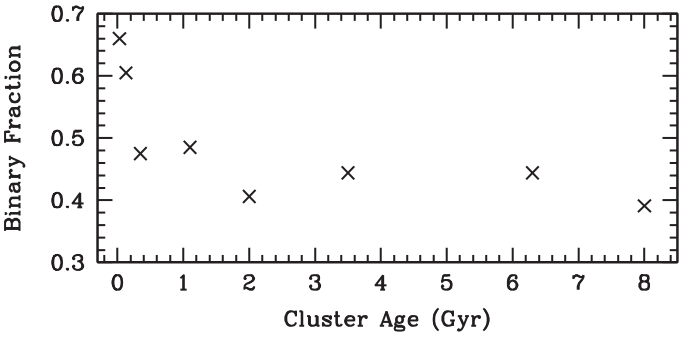

Figure 1. Total binary fraction for the BINCOS clusters sample, which shows a clear rapid decline in binary fraction within the first 200 Myr, and then a slow decline thereafter.

this, stellar parameters and magnitude are cubically interpolated with respect to mass onto a new mass grid, with a spacing of 0.01 $M_{\odot}$ (Thompson & Frinchaboy, 2016)†.

In this work, we present analysis from nine open clusters (M35, M36, M37, M67, NGC 188, NGC 2158, NGC 2420, NGC 6791. NGC 6819), a sample designed to cover a wide range of ages and metallicites within the open cluster population, as well as provide good ties to other open cluster binaries studies for verification. The method depends on having high-quality photometry covering a wide range of wavelengths.

2. Results: Full Sample BINOCS

Using the sample of clusters from the Table below, we find that there is a significant binary population in open clusters, with 60-70% of stars in binary systems. This significant binary population is quickly disrupted within the first 200 Myr, likely the destruction of wide binaries in the cluster environment, with a much slower rate of disruption thereafter as shown (Fig. 1).

3. Results: Intra-Cluster BINOCS

Binary systems are more massive, on average, than a single star, and should therefore experience mass segregation. This has been observationally confirmed for several globular and open clusters (e.g., Geller & Mathieu 2012, Milone *et al.* 2012). Similar analyses, using the two-band photometric detection method have been conducted on the young (15–30 Myr), massive cluster NGC 1818, located in the Large Magellanic Cloud (LMC), producing conflicting results Elson *et al.* (1998) and De Grijs *et al.* (2013). We leveraged our new BINOCS results (using the cluster M3, with binary and mass info, to show that this discrepancy within single star cluster is due to differing mass showing different dynamical ages (Thompson & Frinchaboy, 2016). This results has now also been seen in N-Body simulations (Geller *et al.* 2015)

Reference

Amari, S., Hoppe, P., Zinner, E., & Lewis R. S. 1995, *Meteoritics*, 30, 490

† Software used in this study can be obtained from: https://github.com/bathompso/BINOCS

https://doi.org/10.1017/S174392131501042X Published online by Cambridge University Press