Dynamical Evolution of Dense Stellar Systems
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Defining the Binary Star Population in the Young Open Cluster M35 (NGC 2168)

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Abstract. We present current results from the ongoing WIYN Open Cluster Study radial-velocity survey for 1410 stars in the young (150 Myr) open cluster M35 (NGC 2168) and establish a benchmark for initial conditions in young open clusters. We find for periods $\lesssim$1000 days a minimum binary frequency of 0.36 – 0.51. We also analyze the spatial, period and eccentricity distributions of the binary systems and find that the period and eccentricity distributions are well approximated by scaled field distributions from Duquennoy & Mayor (1991). With our large sample size and long baseline, we have a unique understanding of the binary population in this young cluster, making it ideal for defining initial conditions for dynamical simulations.

Keywords. Stars: binaries: spectroscopic, Galaxy: open clusters: individual (M35 (NGC 2168))

Initial conditions are crucial to the outcome of dynamical simulations (e. g. Hurley *et al.* 2005). We directly measure the binary frequency and period and eccentricity distributions in the dynamically young cluster M35, a fundamental target of the WIYN Open Cluster Study (Mathieu 2000). Our spectra of 1410 stars in the magnitude range $12.5 < V < 16.5$ ($1.5M_\odot < M < 0.7M_\odot$; the turnoff is $V \simeq 9.5$) yield radial velocities with a precision of 0.4 km s^{-1} (Geller *et al.* 2008, in preparation).

We determine cluster membership probabilities for all stars with 3 or more observations using a double Gaussian fit to both the field and cluster velocity distributions, using the center of mass velocities for our 71 binaries with orbital solutions and the average velocity for all other stars. We find 387 members; 243 single and 144 velocity variable systems (of which we have orbital solutions for 45); see Braden, Mathieu & Miebom (2008, in preparation). We find minimum and maximum spectroscopic ($\log(P) \lesssim 3$) binary frequencies of 0.36 ± 0.03 and 0.51 ± 0.05, depending on the membership criteria applied to velocity variable systems.

In Fig. 1 we present the observed period distribution and a scaled distribution of Duquennoy & Mayor (1991); hereafter DM91. Where our sample is complete (to $P \simeq 100$ days), the period distribution is well fit by the DM91 relation. Our observed eccentricity distribution is presented in Fig. 1. The increased number of low-eccentricity orbits is due to tidal circularization of short-period binaries (Meibom & Mathieu 2005). The rest of the distribution is bell-shaped like DM91's sample. This distribution is different than the initial distributions used in cluster simulations to date (e. g. Hurley *et al.* 2005).

Fig. 2 shows the cumulative radial spatial distribution of single and velocity-variable stellar populations in M35. We find that within 4 core radii, single and velocity variable stellar populations cannot be distinguished at the 99% confidence level; the effects of dynamical evolution have not separated the binary and single-star populations in approximately 1 relaxation time (Mathieu 1983). Fig. 2 shows the cumulative radial spatial distributions for proper-motion selected member stars in the $8.0 < V < 14.5$ range (from

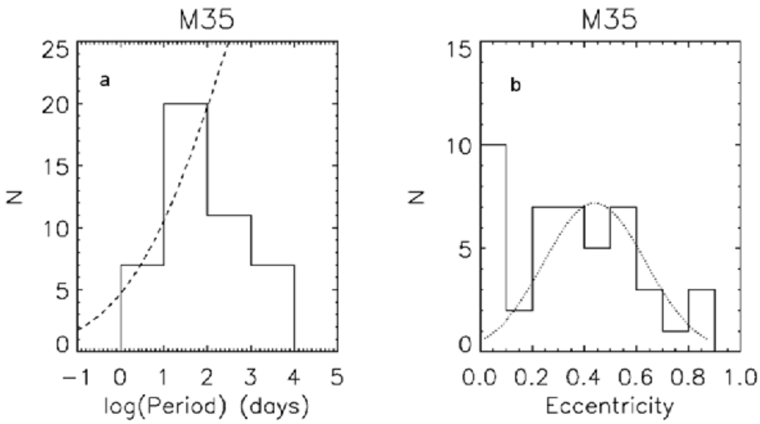

Figure 1. a) Period distribution of binary members systems and the scaled empirical relation of DM91. In the decades where our sample is complete (up to log(P) = 2), the observed number of binary systems matches the relation found by DM91. b) Eccentricity distribution of binary member systems with orbital solutions and a scaled fit to the data in DM91.

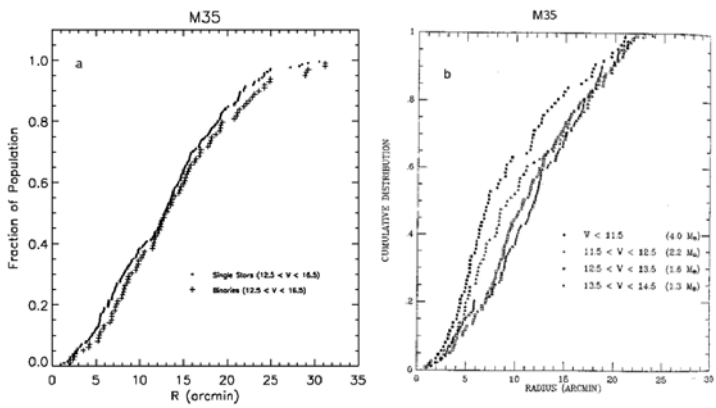

Figure 2. Radial spatial distribution of a) single and binary member systems selected spectroscopically and b) proper-motion selected members divided by magnitude (from Mathieu 1983).

Mathieu 1983) for comparison. While mass segregation is pronounced for the most massive systems ($>2M_{\odot}$), intermediate-mass stars and the solar-type binary population both show very similar spatial distributions.

References

Duquennoy, A. & Mayor, M. 1991, *A & A*, 248, 485
Hurley, J. R., Pols, O. R., Aarseth, S. J., & Tout, C. A. 2005 *MNRAS*, 363, 293
Mathieu, R. D. 1983 PhD thesis, Univ. Calif. Berkeley
Mathieu, R. D. 2000 *PASP*, 198, 517
Meibom, S. & Mathieu, R. D. 2005 *ApJ*, 620, 970

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