The Interplay among Black Holes, Stars and ISM in Galactic Nuclei
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Formation of an IMBH in a dense stellar cluster near the Galactic center

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Abstract. We present results from dynamical Monte Carlo simulations of dense star clusters near the Galactic center (GC). While these clusters spiral in toward the GC by dynamical friction, they could undergo core collapse and form an intermediate mass black hole (IMBH) by runaway collisions. Clusters can reach within a parsec of the GC where, following tidal disruption, they would inject many young stars still bound to the IMBH into the GC region. This scenario (Gerhard 2001; Hansen & Milosavljević 2003) provides a possible explanation for the *youth paradox* raised by recent IR observations (Ghez et al. 2003).†

1. Numerical Technique

We use a Monte Carlo method to simulate the dynamical evolution of dense star clusters. A key advantage of this method is that it allows star-by-star simulations of very large clusters containing up to $N \gtrsim 10^7$ stars (for details and comparison with other methods, see Gürkan et al. 2004). For this work, we introduced an approximate boundary condition at the center of the cluster to be able to follow the evolution beyond core collapse. When a star's apocenter is smaller than a certain value, we remove this star from the simulation and make it a part of a growing central point mass. We do not take these stars into account for calculating the timestep but include their contribution to the gravitational potential. The central point mass represents the collapsed core of the cluster, which, we assume, will eventually form an IMBH.

We follow the approach of McMillan & Portegies Zwart (2003) to calculate the rate of inspiral of the cluster and adjust our tidal boundary accordingly. For a point-like cluster of constant mass, the inspiral time $t_{\rm in}$ can be obtained analytically. A reasonable upper limit for $t_{\rm in}$ is $\sim 10\,$Myr, since it must be less than the lifetime of the brightest IR stars observed near the GC. A lower limit can be obtained by requiring the cluster to undergo core collapse before tidal disruption (otherwise an IMBH cannot form). The core collapse time can be estimated as $t_{\rm cc} \simeq 0.15\, t_{\rm rc}(0)$ (Gürkan et al. 2004), where $t_{\rm rc}(0)$ is the initial central relaxation time, a function of the initial cluster structure. These constraints are shown in Fig. 1 (left) for a King model with dimensionless central potential $W_0 = 9$ and average stellar mass $\langle m \rangle = 0.7 M_\odot$.

2. Results of Simulations

We present typical results for a cluster with 10^6 stars, started at $R_0 = 10\,$pc, on the right side of Fig. 1. The top panel shows Lagrange radii (enclosing fixed fractions of the total bound mass). Core collapse occurs at $t \simeq 1.5\,$Myr. The second panel shows the growth of the central point mass. The horizontal dashed line is the estimate of Gürkan

† Our original poster can be downloaded from:
`http://www.astro.northwestern.edu/~ato/publications/iau222pos1`

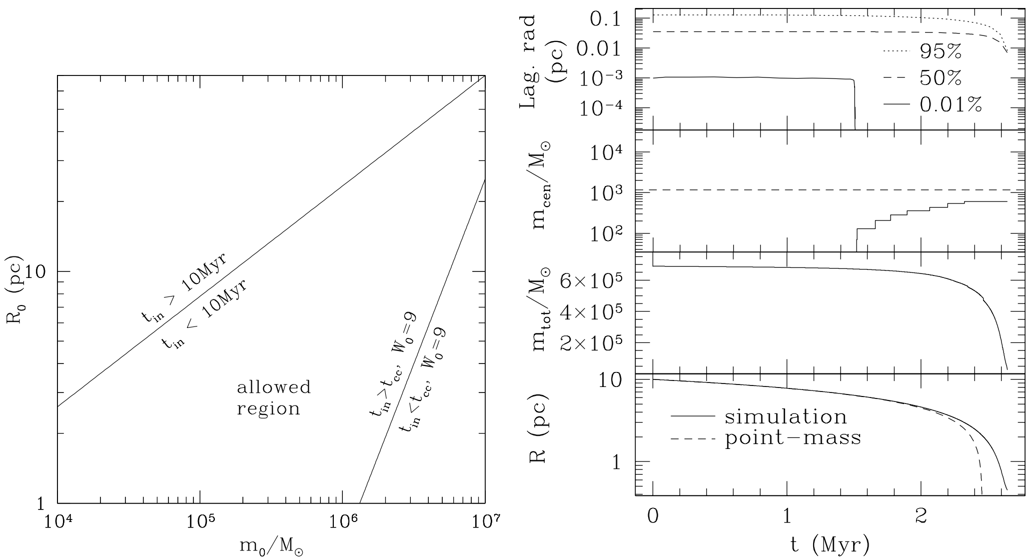

Figure 1. Left: estimates of constraints on initial conditions. Right: results from a typical calculation.

et al. (2004) for the collapsing core mass. The third panel shows the bound mass of the cluster, decreasing rapidly near the tidal disruption radius $R_{\rm dis} \lesssim 1\,\rm pc$. The bottom panel shows the evolution of $R(t)$ in our simulation and in the constant point mass (analytic) approximation.

During the inspiral of the cluster, we record which stars are lost from the tidal boundary. Our results indicate that the heavier stars preferentially remain bound to the cluster until total disruption. This suggests that the tidal truncation cannot catch up with the mass segregation.

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References

Gerhard, O. 2001, ApJ, 546, L39
Ghez, A. M., et al. 2003, ApJ, 586, L127
Gürkan, M. A., Freitag, M., & Rasio, F. A. 2004, ApJ, 604, 632
Hansen, B. M. S., & Milosavljević, M. 2003, ApJ, 593, L77
McMillan, S. L. W., & Portegies Zwart, S. F. 2003, ApJ, 596, 314