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Building Up an Intermediate-Mass Black Hole: The Role of Stellar Collisions

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Intermediate-mass black holes (IMBHs, $10^2 < m_{\text{BH}}/M_{\odot} < 10^5$) populate the poorly constrained mass range between stellar-mass and supermassive black holes. Upcoming gravitational-wave facilities will play a key role in probing this population and its formation channels. In particular, IMBHs and intermediate mass-ratio inspirals involving an IMBH and a stellar-mass compact object will be prime sources for next-generation detectors operating in the deci-Hz band.

Compact, rapidly evolving star clusters are thought to be ideal sites for runaway chains of stellar collisions, forming very massive stars (VMSs, $m_* > 150 M_{\odot}$) that may collapse into IMBHs. However, direct N -body simulations remain computationally challenging in these dense environments.

In this talk, I present a complementary semi-analytic approach to this formation channel. I will introduce STARfall, a code that models the dynamical evolution of a massive stellar binary in a cluster core, incorporating prescriptions for cluster evolution, stellar encounters, and collisions.

I will identify the environments that favor runaway collisions and show how repeated mergers drive the growth of VMSs, the masses they can reach, and how stellar winds determine the final IMBH mass. While dynamics governs VMS growth, stellar evolution sets the final IMBH mass. I will finally discuss implications for present-day globular clusters and high-redshift systems in the Cosmic Gems Arc, highlighting where IMBH seeds are most likely to form.

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