Contribution ID: **21** Type: **Talk**

Simulating intermediate-mass black holes in the first star clusters

Tuesday 27 May 2025 10:36 (12 minutes)

Population III (Pop. III) stars are ideal candidates for the formation of intermediate-mass black holes (IMBHs, $m = 10^2 - 10^5\,\mathrm{M}_\odot$) due to their small mass loss and top-heavy initial mass function. On the other hand, the masses of these IMBHs are typically limited to a few hundred solar masses, restricting their potential as massive black hole seeds. Star cluster dynamics can overcome this limitation, and significantly enhance IMBH growth to higher masses (up to $10^4\,\mathrm{M}_\odot$). This occurs through both runaway stellar mergers and hierarchical binary black hole (BBH) mergers, leading to the formation of increasingly massive black holes. In my talk, I will explore the properties of BBHs and IMBHs in Pop. III star clusters forming at $z > 15$. To simulate these clusters, I used the N-body code PeTar-bseEmp, a state-of-the-art tool that accurately models star cluster dynamics within an external potential while integrating single and binary stellar evolution. I will show how the mass and density of the simulated clusters, and their subsequent evolution, have a significant impact on the formation channels and features of massive black hole seeds. Finally, I will examine the role of star cluster mergers in enhancing the binary black hole merger rate and driving the growth of central IMBHs.

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Session Classification: Observational Science (OSB)

Track Classification: Observational Science (OSB): Div3