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Binary black hole mergers in Population III star clusters

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Population III (Pop III) stars are ideal candidates for the formation of intermediate-mass black holes (IMBHs) because of their small mass loss and top-heavy initial mass function. If such stars were to form in star clusters, their IMBH remnants would have a higher probability of creating binary systems and eventually merge, leaving behind black holes (BHs) massive enough to be seeds of the super-massive black holes we observe now.
In my talk, I will present novel simulations of binary black hole (BBH) formation in Pop III star clusters run with the semi-analytic code `FASTCLUSTER`. I will focus on two extreme cases: the first, in which all first-generation BBHs in the cluster are derived from the evolution of primordial binaries; and the second, in which BBHs are instead formed dynamically because of three-body encounters (hereafter, dynamical BBHs). Either way, we find a large number of BBH mergers with primary masses above the mass gap ($m_1 > 230\,M_\odot$), contrary to what is expected in the case of Pop III isolated binaries, which show a primary mass distribution peaking at $m_1 \sim 30\,M_\odot$ and few or no mergers in the IMBH mass range. Notably, we observe that in our simulations the primary BH mass has a peak at $m_1 \geq 500 M_\odot$ when the BBHs are dynamical and sampled with a distribution that favors high-mass BHs. Depending on both their final relativistic kick, and on dynamical interactions, a number of remnant BHs will be able to form a chain of mergers. I will show that in our simulated clusters we form supermassive black hole seeds of 10^3 $\mathrm{M}_\odot$ via hierarchical BBH mergers by $z = 10$.

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