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A Scenario for MBH Seed Formation Driven by Runaway Stellar Collisions in Galactic Nuclei

We discuss a proposed formation scenario for massive black holes (MBHs) seeds driven by a global instability of stellar clusters in galactic nuclei (NSCs), which is triggered by runaway stellar collisions (Escala 2021). We first show that observed NSCs avoid the regime where stellar collisions are dynamically relevant over the whole system, while resolved detections of MBHs are well into such collision-dominated regimes. We also test the proposed scenario for direct MBH by runaway stellar collisions in NSCs, using n-body numerical simulations that follows such stellar collisions in simulated clusters (with N-body6++; Vergara et al 2023, 2025), showing that dense enough NSCs can be indeed globally unstable against stellar collisions, resulting in MBH formation efficiencies as high as 50% of the final simulated cluster. We extend this result studying the efficiency of black hole formation via collisions in stellar systems in general, including GCs and UCDs, finding that the black hole formation efficiency is shown to be strongly influenced by the condition of global instability in those systems (Vergara et al 2024). This collision-driven seed scenario, depends on a collapsing Very Massive (quasi-)Star as in other direct MBH formation scenarios, thus a gravitational-wave signal is expected from galactic centers at the moment of final collapse and MBH formation.

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