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Formation of globular clusters with intermediate-mass black holes

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The formation process of star clusters has not been fully understood yet. Recent numerical simulations of star-cluster formation are reaching the mass of globular clusters (1e6 Msun). However, in hydrodynamics simulation with N-body, the stars have been treated as super particles, representing several stars as one particle. We have developed a new N-body/smoothed-particle hydrodynamics (SPH) code, ASURA+BRIDGE, and have performed N-body/SPH simulations of forming star clusters with almost 1e6 Msun by resolving individual stars. Our code can integrate the orbits of stars without gravitational softening using a direct-tree hybrid N-body code, PeTar (Wang et al. 2020), combined with our N-body/SPH simulation code, ASURA+BRIGE (Fujii et al. 2021). In our simulations, runaway collisions of stars occurred in the forming globular clusters, and the mass of the very massive stars (VMSs) formed via runaway collisions reached a maximum of 1e4 Msun. According to a stellar evolution model, they can collapse to IMBHs with a mass of a few thousand Msun. Our results suggest that some globular clusters may host an IMBH more massive than 1000 Msun. In addition, such VMSs quickly lose their mass via stellar wind and pollute the surrounding gas. In our simulations, so-called second population stars are also formed from the polluted gas. They typically have more than 0.1% of the mass originating from the VMS.

Affliation

The University of Tokyo

Current Position

Senior Scientist or Faculty

Primary author: FUJII, Michiko (The University of Tokyo)

Presenter: FUJII, Michiko (The University of Tokyo)

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