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Star Cluster Formation: The effects of early forming massive stars and building a bridge between Voronoi mesh and block-structured codes

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An ideal computational star formation simulation would track an enormous spatial scale that included galactic dynamics and retained detail down to the physics of single stars. However, such ambitions are computationally prohibitive. We attempt to bridge this gap between galaxy simulations and simulations of individual star forming clouds. We extract giant molecular cloud (GMC) structures and dynamics from AREPO Voronoi mesh galaxy simulations and use VorAMR, a new software package we have developed, to interpolate the Voronoi mesh onto an octree adaptive grid suitable for use with the FLASH adaptive mesh refinement code. We then use the converted data as initial conditions for our software suite Torch which couples FLASH into the Astrophysical Multipurpose Software Environment (AMUSE), thus coupling magnetohydrodynamics and N-body dynamics for detailed self-consistent star cluster formation. This technique allows us to track the dynamics and feedback physics of individual stars computed with Torch in the context of a collapsing GMC that formed under self-consistent galactic conditions simulated by AREPO. VorAMR also serves as an effective tool to better visualize Voronoi mesh output using tools designed for adaptive meshes such as the yt-project. Visualization software often treats Voronoi mesh data as smoothed particle hydrodynamics particles, resulting in loss of resolution while our method more closely retains the original Voronoi mesh resolution.

Also using the Torch computational framework, we test the hypothesis that the timing of massive star formation plays a vital role in the star formation and assembly of star clusters. We find that early forming massive stars (exceeding 50 solar masses) disrupt the natal gas cloud, limiting global star formation efficiency by up to a factor of three when compared with our control model. Early forming massive stars also promote the formation of stellar subclusters and hinder their assembly into a single young massive cluster while the control model readily forms such a cluster.