Dawn: Simulations of the formation and early evolution of embedded clusters

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The star formation and the dynamical evolution of star clusters are often studied separately in the literature. Compelling models have been developed to describe how stars form within large molecular clouds and how the resulting star clusters evolve and disperse inside the galactic field. However, these two processes do not occur sequentially but simultaneously during the life cycle of a star-forming region, and newborn stars are strongly connected to their environment during their early dynamical evolution. During this phase, stars and molecular gas of a star-forming region are coupled through star formation, stellar feedback and gravitational interactions. These complex and multiple interplays complicate our understanding of stellar formation and dynamical evolution in such regions, making their modeling very challenging through numerical simulations.

New techniques and compromises in numerical resolution are therefore necessary to generate a large number of simulations of young cluster dynamics, which is essential to identify preferred evolutionary pathways from the molecular cloud collapse to the cluster emergence. This presentation will describe the new methods that have been integrated into `Phantom` and enable highly efficient simulations of giant molecular cloud collapse. I will first introduce a novel star formation recipe that uses a subgrid model to create individual stars inside large sink particles, before presenting several state-of-the-art methods for collisional stellar dynamics that I implemented in `Phantom`. These are composed of a fourth-order time integration scheme, which is now the default option in the code, and regularisation algorithms to handle close encounters, hard binaries, multiples and their secular evolution. In the following, I will describe the implementation of H II region expansions to model feedback in our simulations. I will also present a new option to push sink particles in the tree for faster sink-gas gravitational interactions. Finally, I will present the first results of this new simulation framework applied to typical giant molecular clouds.