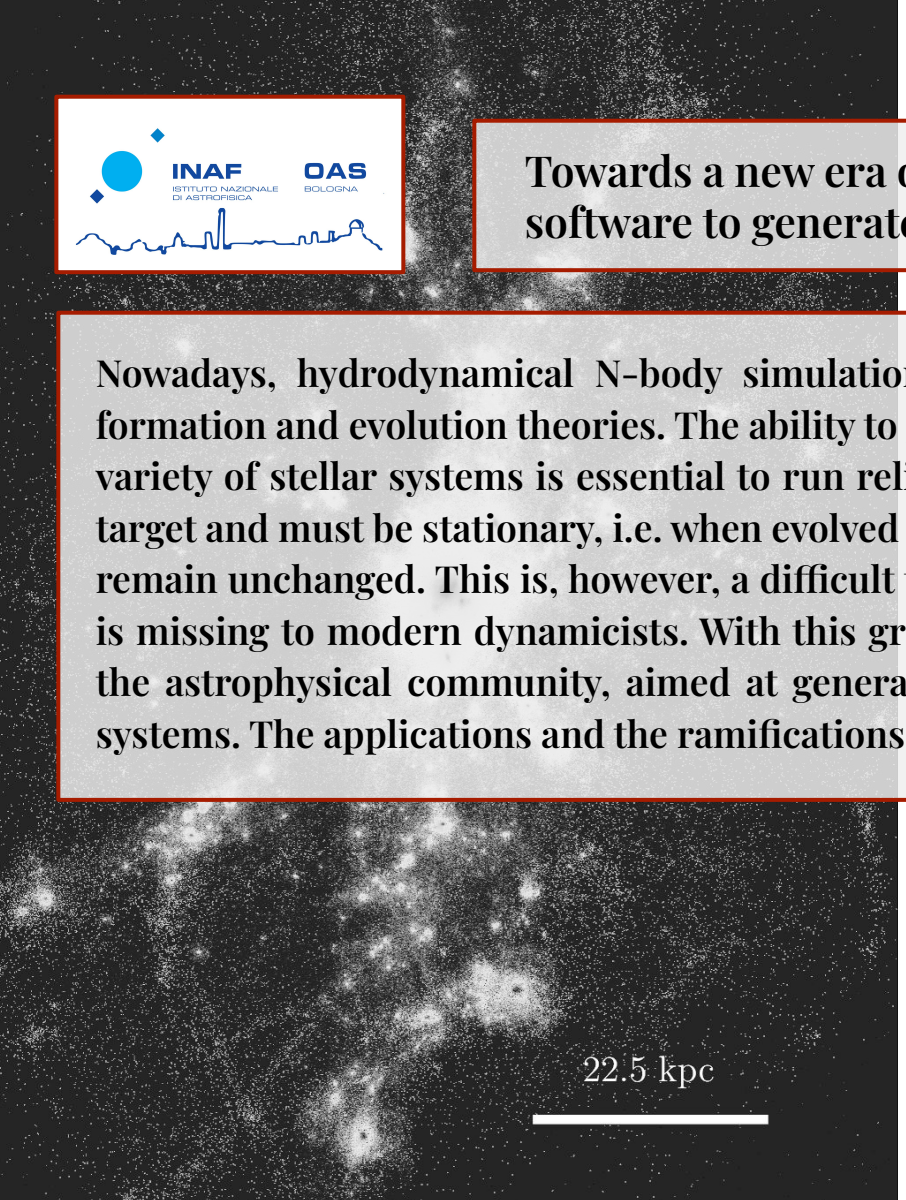
Towards a new era of hydrodynamic N-body simulations: a novel software to generate galactic initial conditions

Nowadays, hydrodynamical N-body simulations are by far the most used method to test galaxy formation and evolution theories. The ability to generate accurate initial conditions (ICs) for the largest variety of stellar systems is essential to run reliable N-body models. ICs must represent faithfully the target and must be stationary, i.e. when evolved in isolation their overall structure and kinematics must remain unchanged. This is, however, a difficult task and an easy, flexible and free access ICs generator is missing to modern dynamicists. With this grant, I plan to develop a software, publicly available for the astrophysical community, aimed at generating ICs for the largest variety of galaxies and stellar systems. The applications and the ramifications of such work would be countless.



MINIGRANT RSN 2022
PI: Raffaele Pascale (INAF-OAS),
Scheda: Proto-Globular Clusters in Numerical simulations and in lensed fields
Funds: 10600 euros

STATUS

Expanses:

- purchase of materials
- Participation at the STARS conference (Naples)
- Participation at the EAS 2023 conference (Krakov)

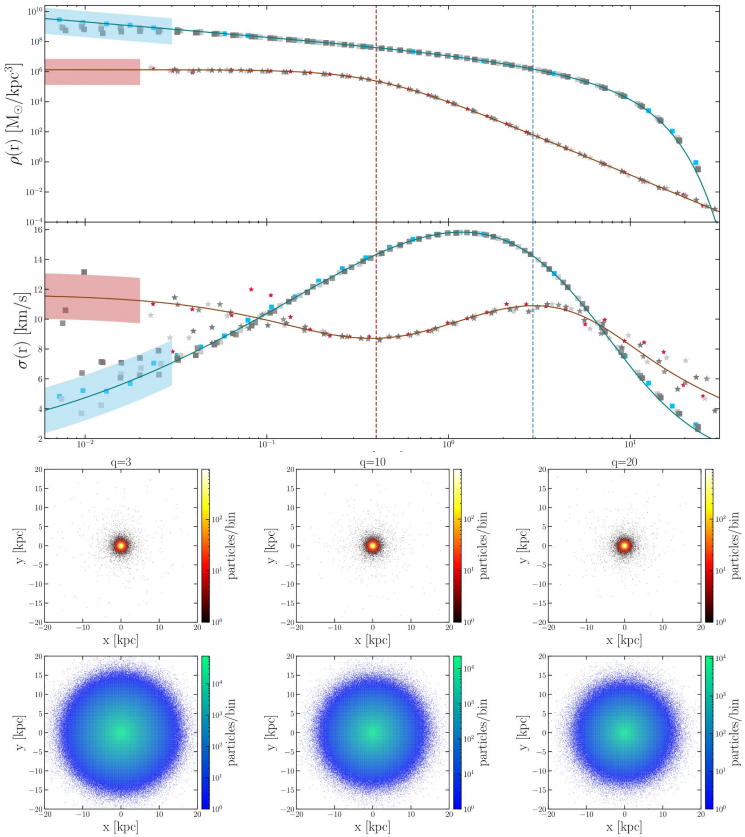
Achieved:

- implementation of models to sample initial conditions for one-component and multicomponent stellar systems, with particular emphasis on globular clusters and dwarf, dark matter dominated galaxies.
- Implementation of new methods for particle sampling
- Implementation of new Poisson Solver methods
- Tests of the above methods with a limited number of particles
- partial porting on python and cython of a previous version of the code privately distributed

Next steps:

- Completion of python and cython poring
- Implementation of additional, more flexible models specifically designed to handle disk galaxies.
- Run additional test (with larger number of particles) covering the whole range of models implemented

No relevant difficulties so far



Example of initial conditions (ICs) of a two-component galaxy (stars in red and dark matter in blue). The ICs have been evolved in time using the AREPO code to check their equilibrium state. The top panels show the density distribution and velocity dispersion of both components (points) compared to the prediction of the analytic model used to sample the ICs. The bottom panels show the on-plane density projections of the ICs (left) and two subsequent snapshots of the simulation. The ICs remain in equilibrium.

Publications and related projects:

- Pascale et al. 2023 (submitted)
- Pederzoli et al. (+Pascale) in preparation
- Supervision of Master thesis a project partially dedicated to code development