Evolution of OB associations in the Milky Way

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Motivation

Many of the OB stars are born in the associations. Therefore, we need to be able to model the evolution of OB associations in order to investigate how properties of populations of OB stars and their progenies, neutron stars and black holes, are affected by that phase of their lifes. Some aspects of such modelling are discussed further.

Simulation details

The evolution of OB association is modelled taking into account stellar dynamics, hydrodynamics of gas, evolution of stars and their interaction: stars-gas gravitational interaction, feedback from stellar evolution to hydrodynamics via winds and supernova outbursts and feedback from stellar evolution to stellar dynamics via supernova kicks. More sophisticated processes such as binaries evolution and interactions, radiation transfer and stellar formation during the run of simulation are not modelled.

Initial conditions

In general, initial conditions are based on properties of Sco OB2 association and molecular clouds. However, in this particular simulation hydrodynamic initial conditions are unrealistic.

Stellar dynamics:

- Number of stars — 2500
- Total mass of stars $\approx 1400 M_\odot$
- Initial mass function

$$\xi(m) = \begin{cases} m^{-0.96}, & 0.1M_\odot < m < 0.6M_\odot \\ m^{-2.8}, & 0.6M_\odot < m < 2M_\odot \\ m^{-2.6}, & 2M_\odot < m < 100M_\odot \end{cases}$$

- Radius of association — 10 parsecs
- Spatial distribution of stars is fractal with dimension $D = 2.4$

Stellar evolution:

- Solar metallicity
- Gaussian supernova kick distribution with mean velocity $v = 400$ km/s and dispersion $\sigma_v = 250$ km/s

Hydrodynamics:

- Mass of gas $\approx 300 M_\odot$
- Number of gas particles — 5000
- Plummer spatial distribution

Times:

- Total simulation time — 4.2 Myr
- Interval for feedback from stellar evolution — 0.01 Myr
- Interval for gas-stars gravity interaction — 0.04 Myr

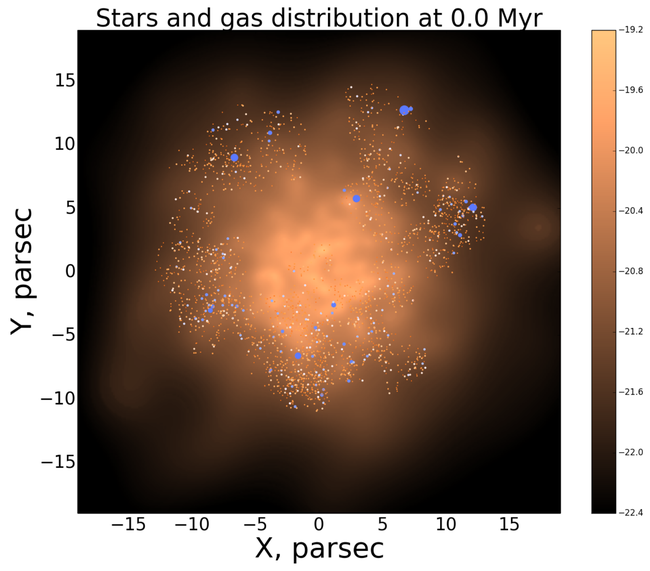
Technical details

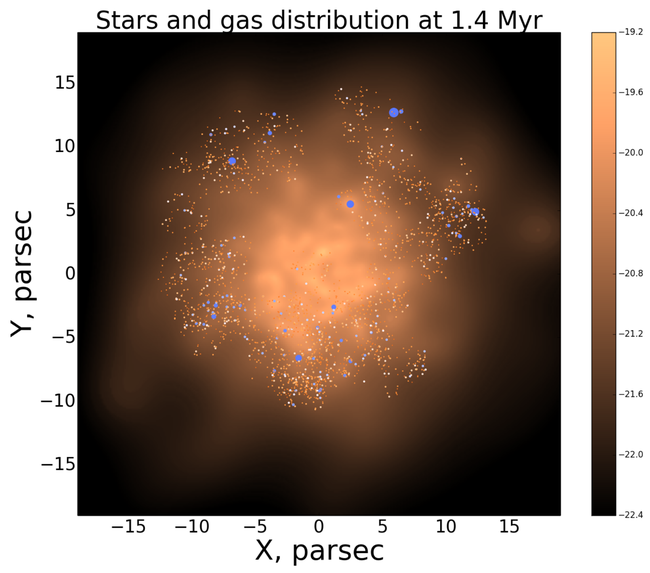
The simulation is performed using the existing solvers for different domains coupled together by the AMUSE framework.

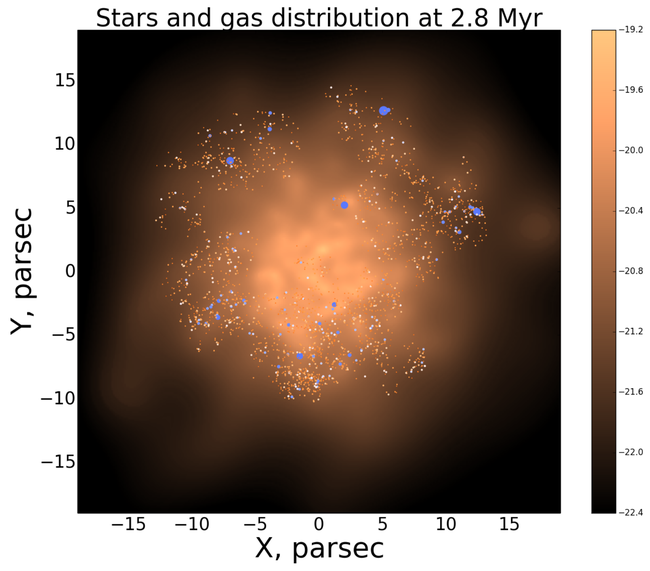
Solvers:

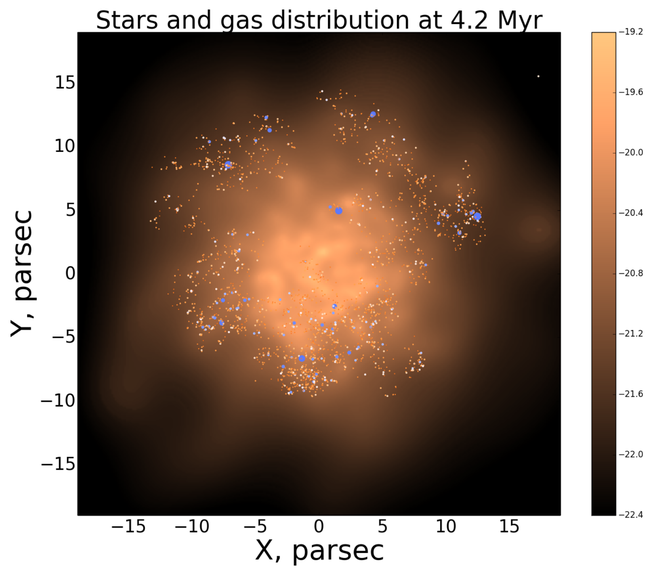
- N-body — PhiGRAPE
- Hydrodynamics — GADGET2
- Stellar evolution — SeBa
- Gas gravitation — Octgrav

Evolution of spatial distribution

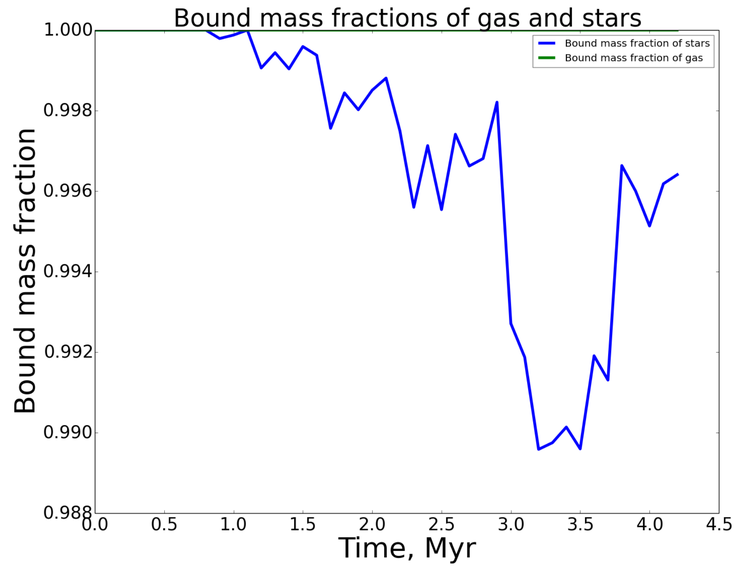


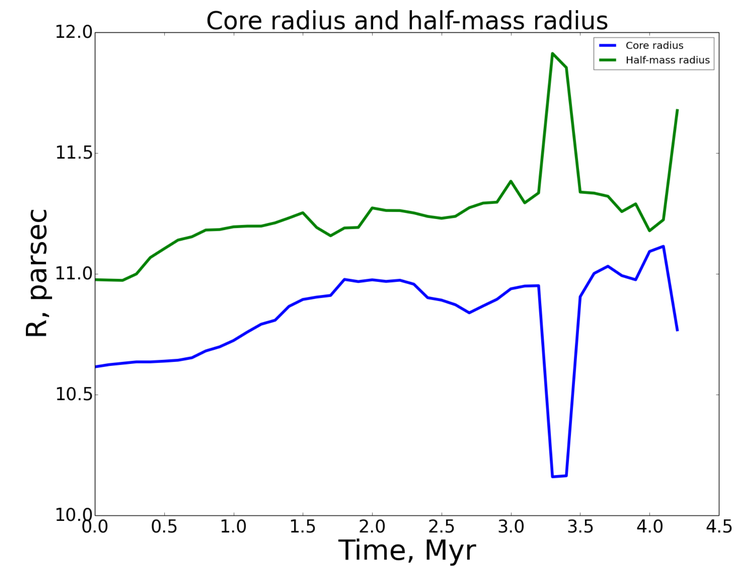


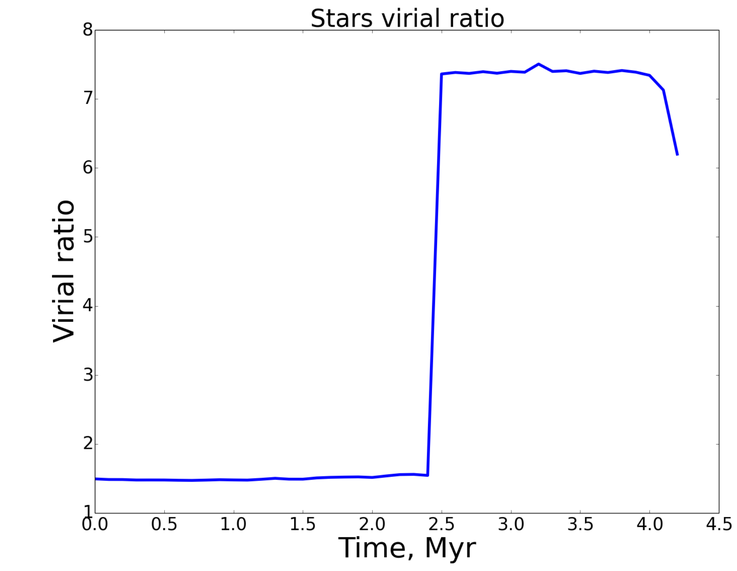


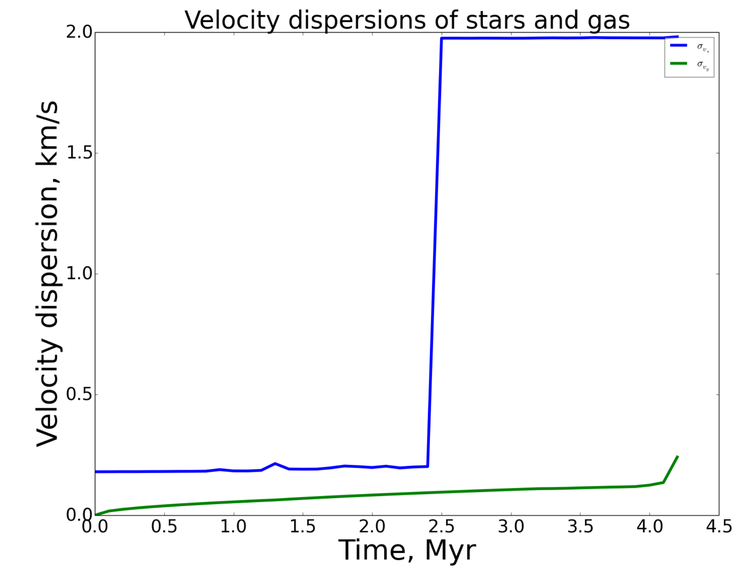


Evolution of kinematic characteristics









Conclusions

Now we have an ability to simulate the evolution of OB association taking into account stellar dynamics, hydrodynamics of gas and stellar evolution. However, before proper modelling of whole population of OB associations in the Milky Way we need carefully test our technique, add more complicated processes such as binary evolution and multiple interactions and thoroughly investigate initial conditions and parameters. This will be our next goals.