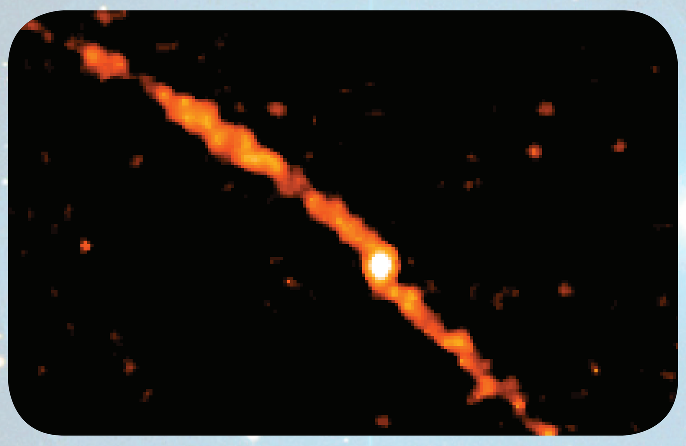
What happens to open clusters in the galaxy?

Cluster origin and evolution in the galaxy

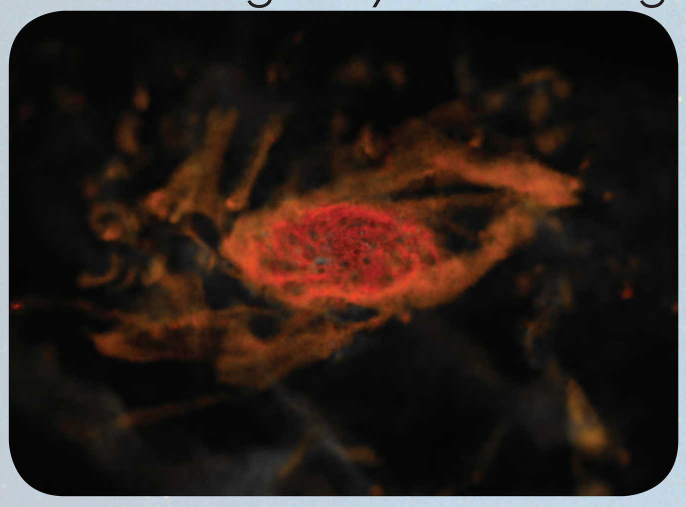
Open clusters form in the galactic disk, from giant molecular clouds. After stars have formed, remaining gas is blown out of the cluster by stellar winds. Clusters still interact via tidal forces with their host galaxy. These forces stretch the star clusters as they move through the galaxy, stripping stars that exceed the tidal radius of the cluster. Gradually, star clusters disperse and its stars become field stars.

A cluster with tidal streams



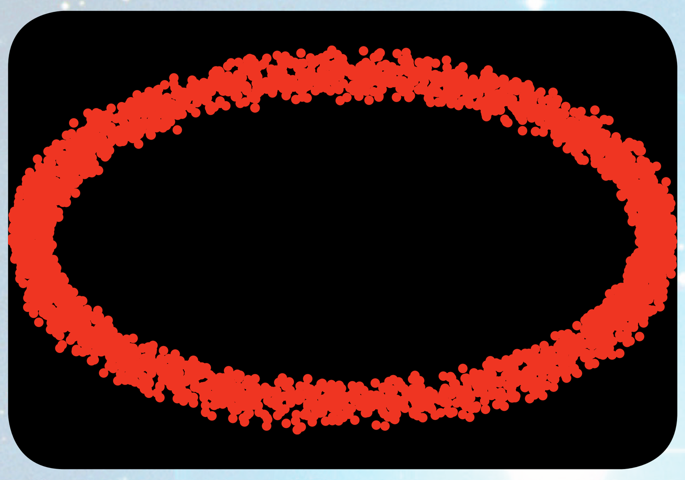
In hydrodynamical galaxy simulations, star formation is represented by converting gas particles into star particles (each representing many solar masses). Star clusters are likely to form at and follow the trajectory of such star particles.

Simulated galaxy disk forming



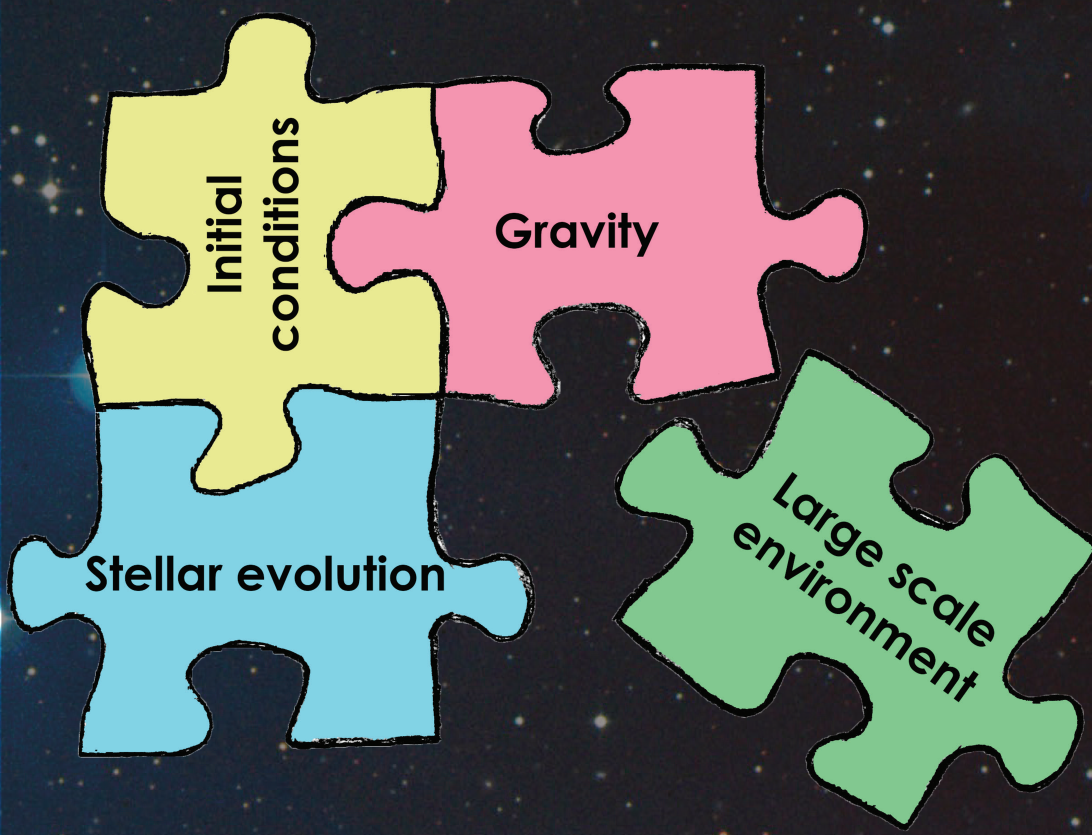
To investigate the tidal effects from a galaxy on clusters, we use a Milky Way-type galaxy simulation (including stars, gas and dark matter). From this simulation, we select all star particles at approximately solar distance from the galactic center (8±0.5 kpc) in the final snapshot. We locate these star particles in each earlier snapshot of the simulation and calculate the tidal field experienced by each.

All selected star particles



Simulations made easy

The Astrophysical Multipurpose Software Environment **AMUSE** allows for the combination and interchanging of simulation codes. It contains various codes for gravity, stellar evolution, hydrodynamics and radiative transfer, each with their own benefits and drawbacks. AMUSE uses python to interface with each of these codes.



We use AMUSE to combine a previously calculated galaxy simulation with smaller scale star cluster simulations. This way, the galaxy provides the tidal field in which the smaller system evolves.

Get AMUSE from http://amusecode.org

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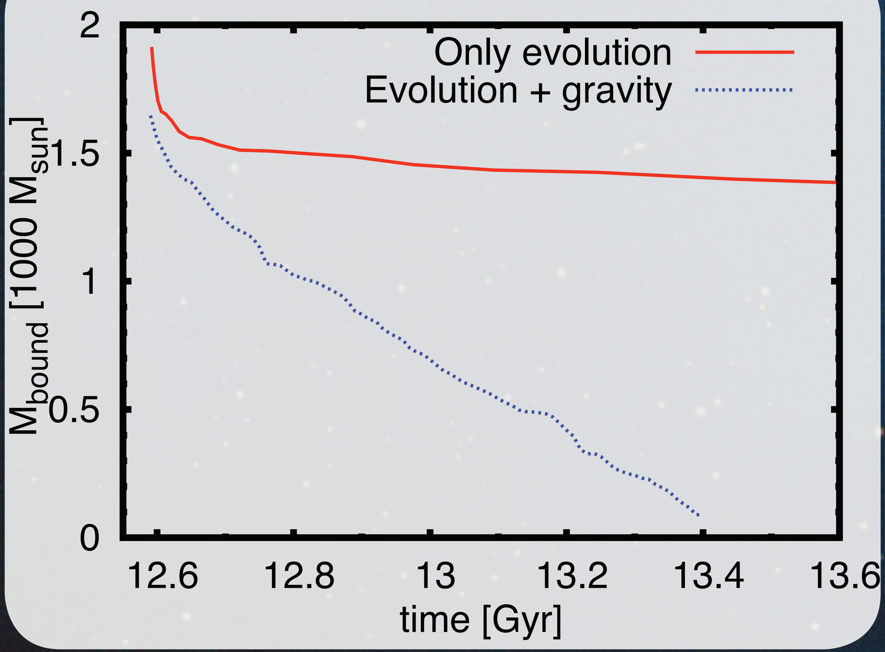
Cluster evolution

At the start of the main sequence, we describe the distribution of star cluster masses and radii with a Schechter distribution for the mass, and a LogNormal distribution for the radius. We use a Kroupa IMF to assign masses to stars

Initially, stellar evolution will dominate the cluster's mass loss as massive stars are removed. This reduces the cluster's bound mass and, in turn, its tidal radius.

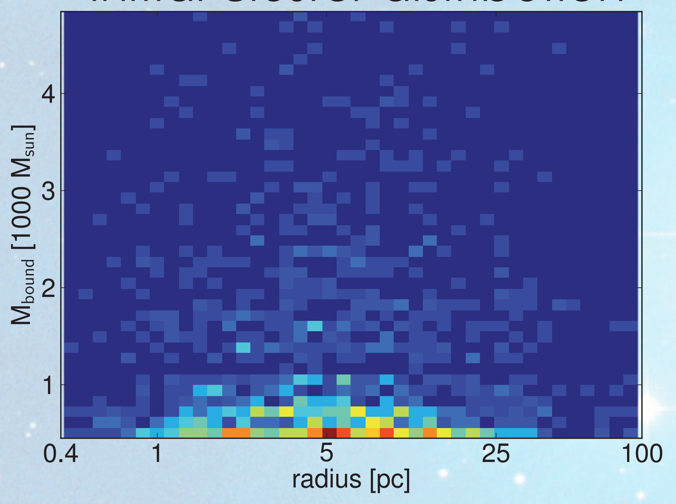
Later, gravity and the tidal field become the major causes for mass loss from the cluster. Tidal stripping removes stars in the outskirts, and three-body encounters in the core eject stars from the cluster.

Mass loss from stellar evolution



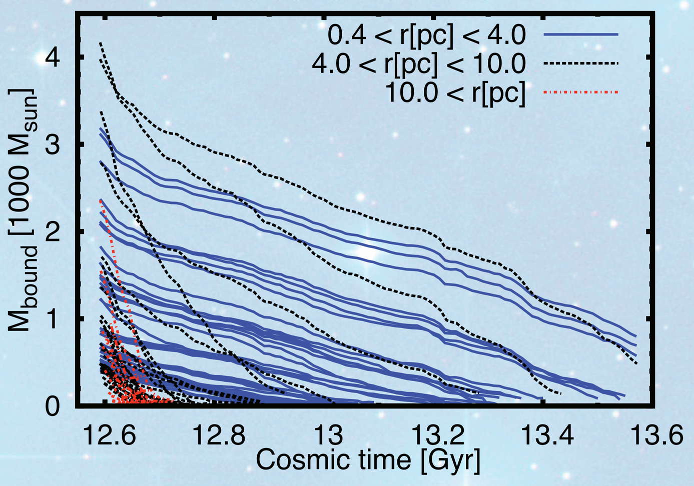
All star clusters disrupted within a Gyr

Initial cluster distribution



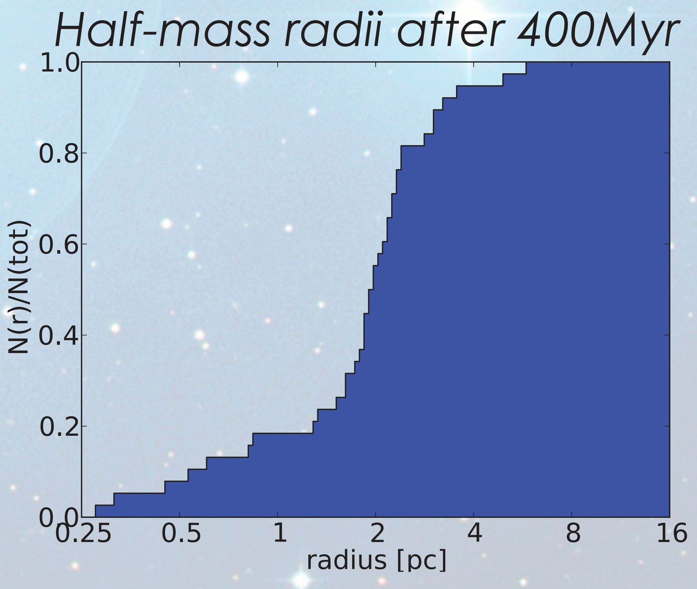
From a galaxy simulation, we obtain tidal fields representative for open clusters in the solar neighbourhood. We randomly sample a set of 100 star clusters from a representative initial cluster distribution. We simulate these clusters with the tidal fields, combining the effects of gravity, stellar evolution and the tidal field in these simulations.

Mass evolution



We find that the most extended (R > 10 pc) clusters are disrupted within 100Myr. More compact clusters can survive up to about 1Gyr, depending on their masses. The mass loss rate of the clusters depends on the tidal field as well as the initial radii of the clusters.

Half-mass radii after 400Myr



After a few 100Myr, the half mass radii of the clusters show a sharp peak at about 2 parsec. This is independent of the initial parameters of the clusters. Stars in the outskirts of the clusters are stripped, whereas compact clusters get 'puffed up' by the tidal field and gravitational interactions.