MCMD: Time evolution of stellar clusters

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Objective

Given a cluster of a million stars, what is the likely time evolution of the population of main sequence stars and remnants, cluster mass and the mass/luminosity ratio over a period of 15 Gyr?

Distribution of stellar mass

We are provided the distribution

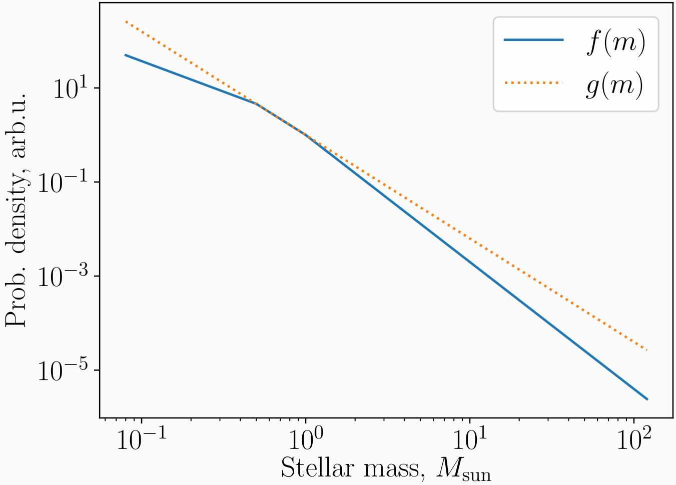
$$f(m) = m^{-\gamma}$$

with $\gamma = 1.3$ for $0.08 < m < 0.5$, $\gamma = 2.2$ for $0.5 < m < 1$ and $\gamma = 2.7$ for $1 < m < 120$.

We use importance sampling with $g(m) = m^{-2.2} \geq f(m)$ and can now sample random stellar clusters.

We will sample the statistics from 10,000 iterations of the cluster.

Distribution of stellar mass



Stellar lifetimes

The lifetime of a main sequence star is

$$\tau = 10^{10} \left(\frac{m}{M_{\mathrm{sun}}} \right)^{-2.5} \mathrm{yr}$$

We assume that the masses are constant during the lifetimes of the stars.

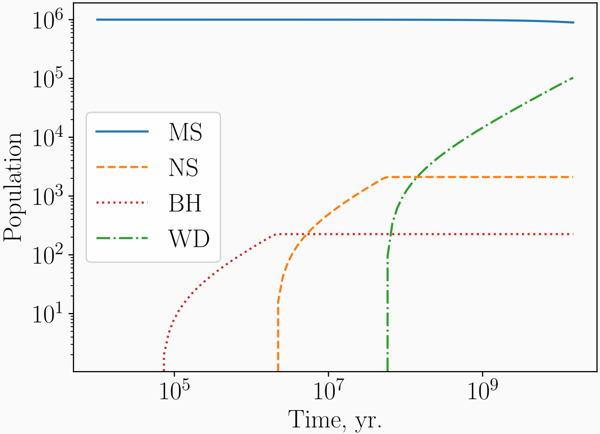
Remnants

Depending on the mass of the star it can become one of three types of remnants

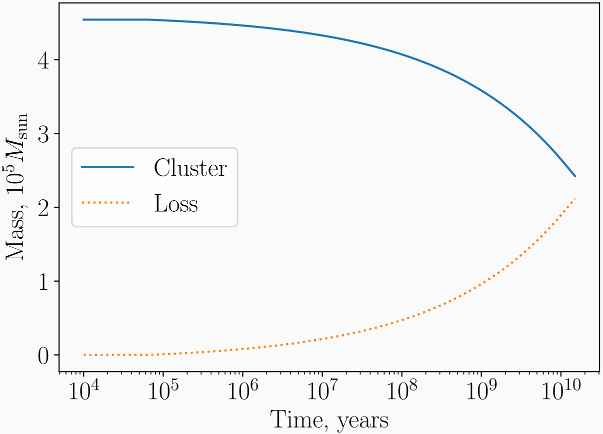
Type	Mass	Star mass	Creation time, yr.
White dwarf	0.6	0.08 – 8	$5.5 \cdot 10^7 - 5.5 \cdot 10^{12}$
Neutron star	1.4	8 – 30	$2.0 \cdot 10^6 - 5.5 \cdot 10^7$
Black hole	10	30 – 120	$6.3 \cdot 10^4 - 2.0 \cdot 10^6$

Remnants have zero luminosity!

Time evolution – population



Time evolution – mass



Luminosity

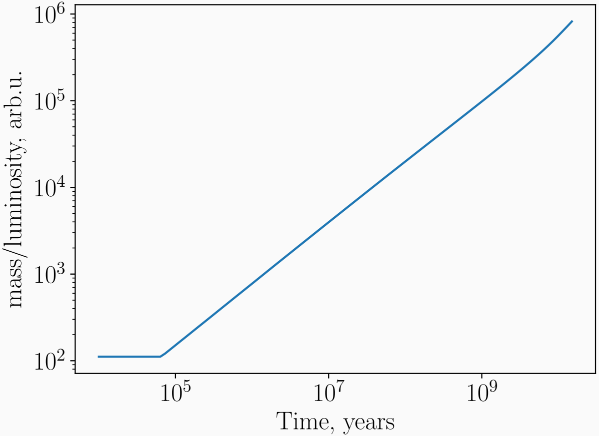
From a very rough model we assume that luminosity and mass are constant during the lifetime of the star and their ratio is related to the lifetime

$$\tau \propto \frac{m}{L}$$

Hence, in some appropriate system of units,

$$L = \frac{m}{\tau}$$

Time evolution – mass-luminosity ratio



Surviving stars have a large lifetime, hence larger m/L-ratio!

State after 12 Gyr

After 12 Gyr the average population is

Type	MS stars	White dwarfs	Neutron stars	Black holes
Number	908772	88896	2107	225