HOW EFFICIENT IS ACCRETION ONTO A PROTOPLANETARY DISC?

DIALOGUE CONCERNING A FORMATION MECHANISM OF TWO (OR MORE) POPULATIONS IN GLOBULAR CLUSTERS

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Pick your cue card

PERSON 1

This figure *<point at lower left corner>* illustrates the scenario in which an enriched population is formed without invoking multiple epochs of star formation.

The low-mass pre-main-sequence stars sweep up gas expelled by the more massive stars of the same generation into their protoplanetary disc as they move through the cluster's core [1].

They need to accrete roughly their initial mass to explain the observed abundances, which is of the order of a 100 times the disc mass!

PERSON 2

Interesting! Somebody has to test if this is actually plausible. It would be even better to find a relation between the initial conditions and how much gas can be accreted.

For example, how does the accretion rate depend on the density and velocity of the gas and the radius and surface density profile of the disc (as a function of time)?

That way you can use it in a large-scale star cluster simulation.

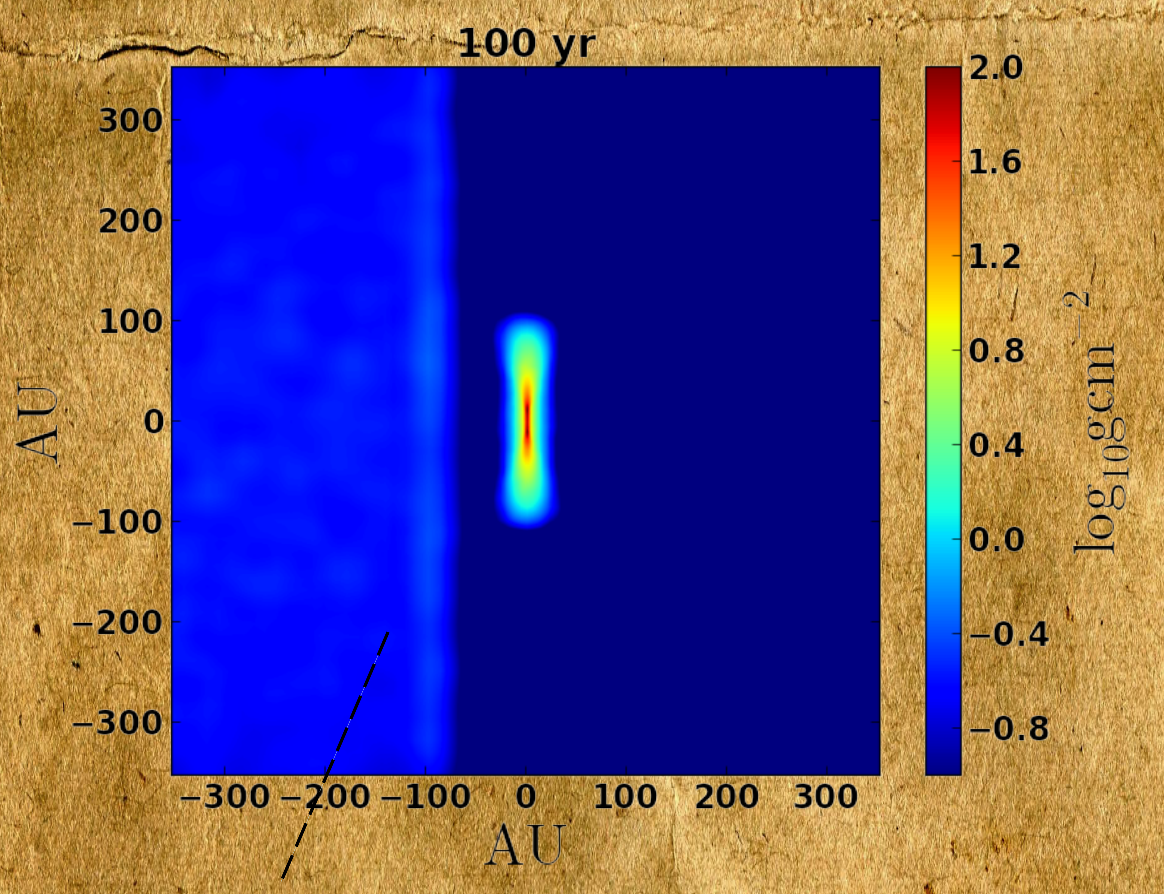
PERSON 3

That's exactly what we are doing using SPH codes [2] through the AMUSE framework [3].

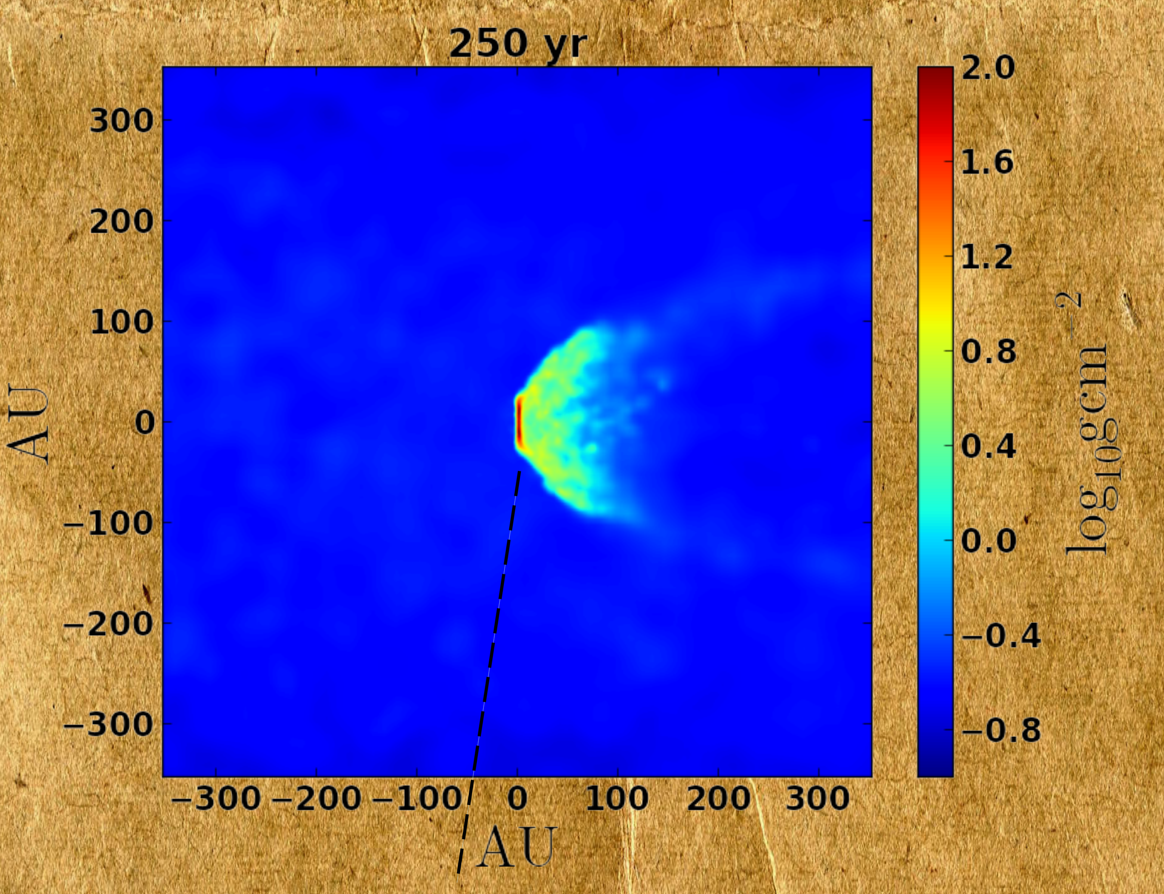
Looking at the sequence in the middle, you can see that, to first order, the RAM pressure determines the size of disc.

However, this figure *<point at lower right figure>* shows that the 'effective' surface of the disc is smaller than the actual surface. We are still in the process of interpreting this difference.

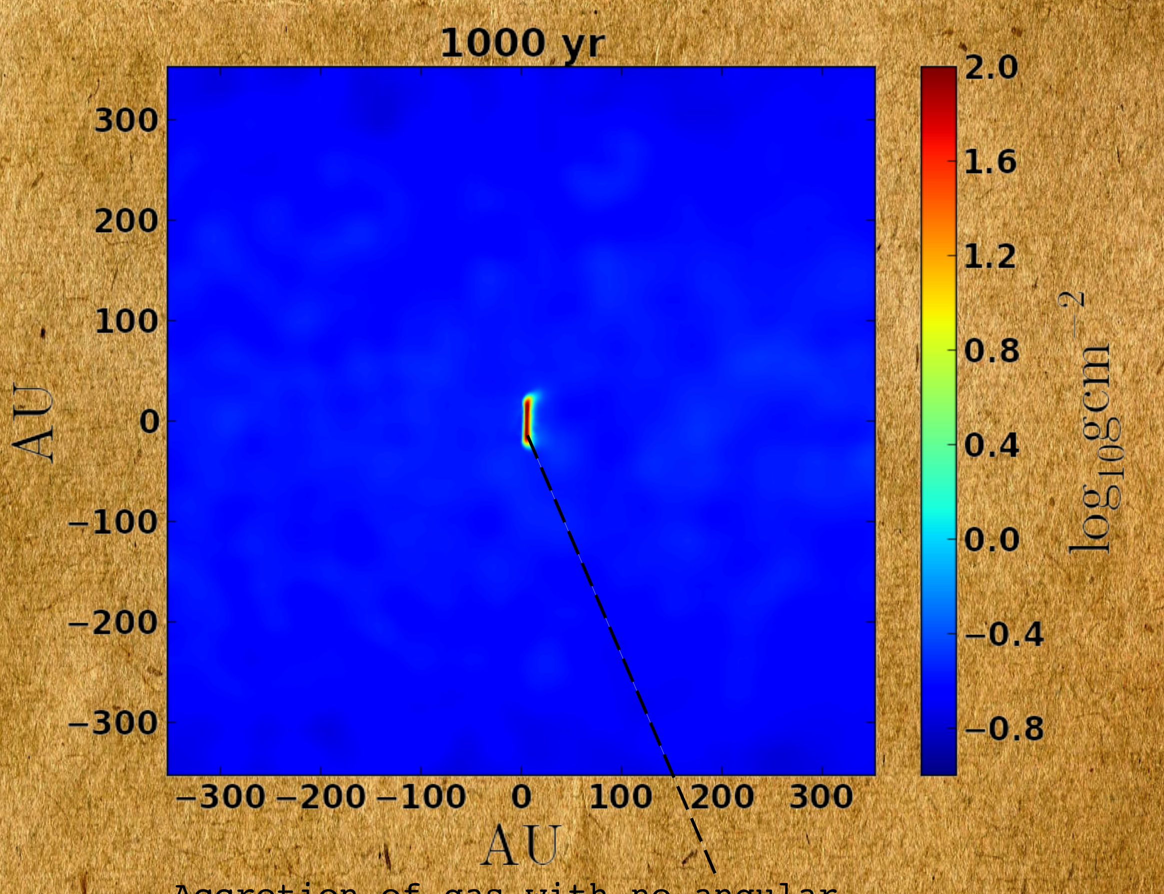
<There is some room for discussion here>



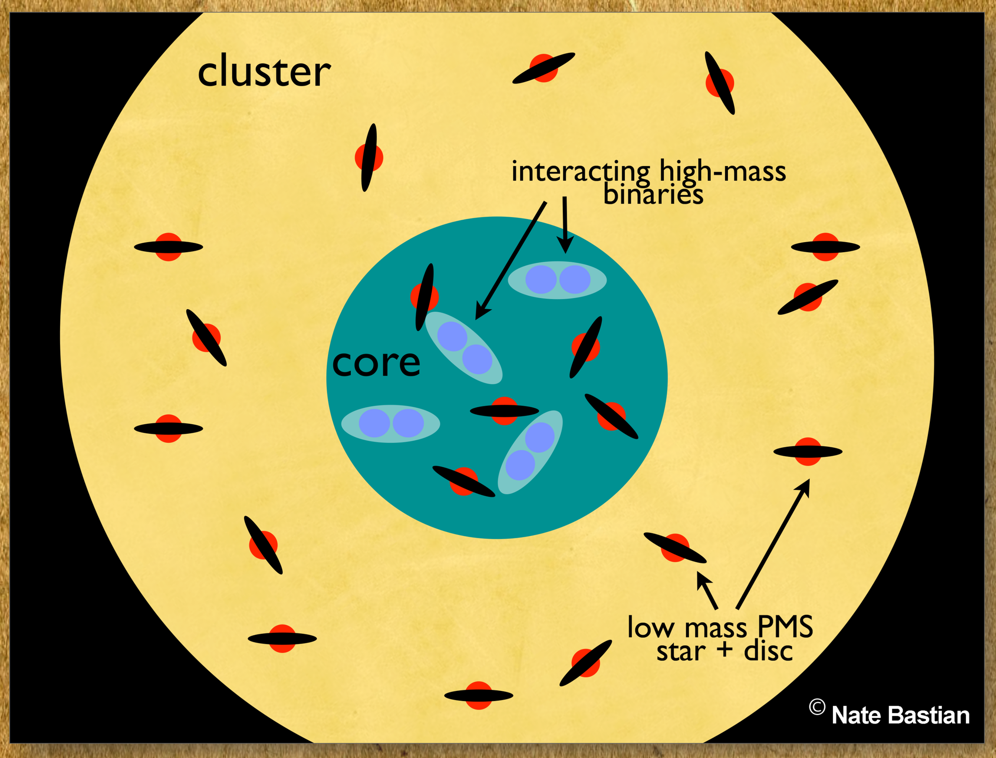
The 'enriched' gas flows in from the left towards the stationary star and disc.



For the initial conditions in this simulation, the RAM pressure ($=\rho v^2$) is higher than the disc pressure in the outer layers.

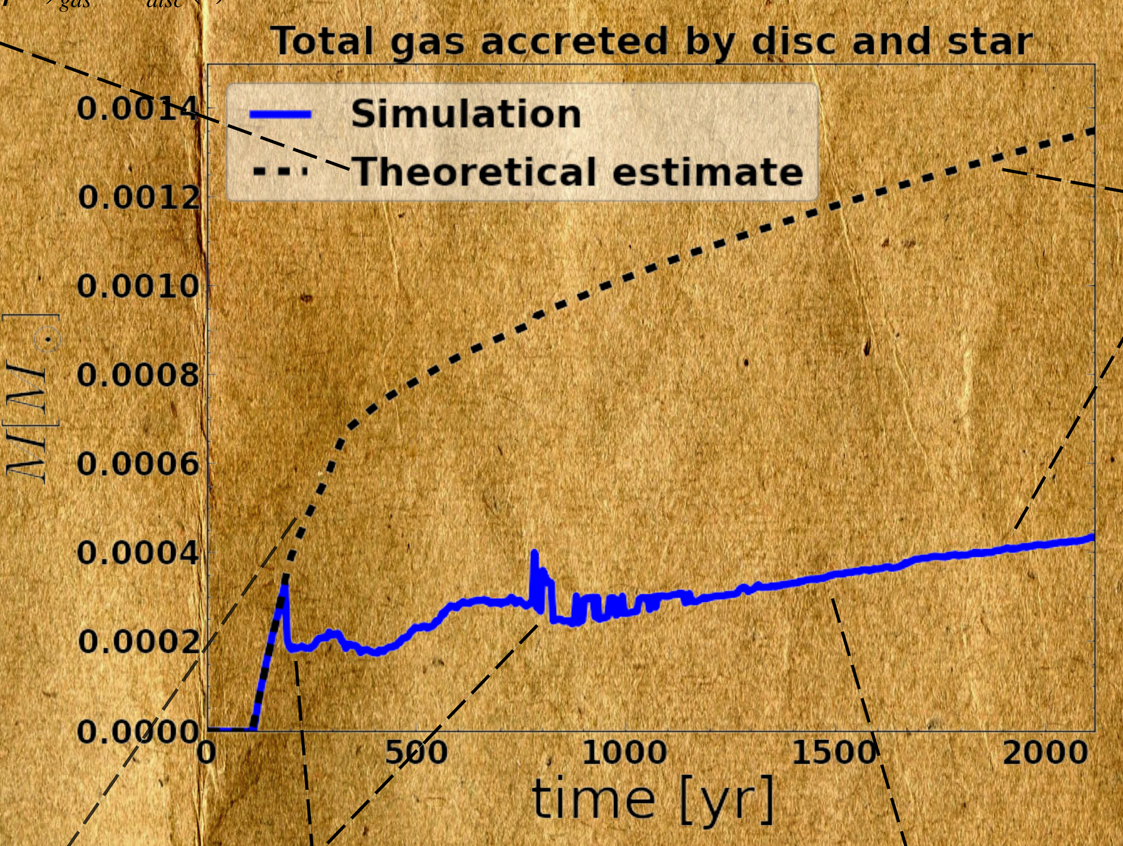


Accretion of gas with no angular momentum redistributes mass inwards until the disc radius reaches an equilibrium value.



The 'Early Disc Accretion' scenario [1].

Assuming $M(t)=(\rho v)_{gas}\pi R^2_{disc}(t)$



The difference between these slopes tells us that the 'effective' surface of the disc is smaller than its actual surface.

By 'effective' surface we mean the surface for which the measured accretion rate corresponds to the theoretical value.

When the outer layers are stripped, it is hard to determine which material belongs to the disc and which not.

We therefore also overestimate the disc radius in the beginning.

Eventually the disc is clearly defined.

References:

1. Bastian N., Lamers H. J. G. L. M., de Mink S. E., Longmore S. N., Goodwin S. P., Gieles, M. (2013) Early disc accretion as the origin of abundance anomalies in globular clusters. MNRAS, Vol. 436, Issue 3, p.2398-2411
2. Fi: Pelupessy F. I., van der Werf P. P., Icke, V. (2004) Periodic bursts of star formation in irregular galaxies. A&A, Vol. 422, p.55-64
3. www.amusecode.org

AMUSE

Radboud University