Dynamical friction and gas inhomogenities

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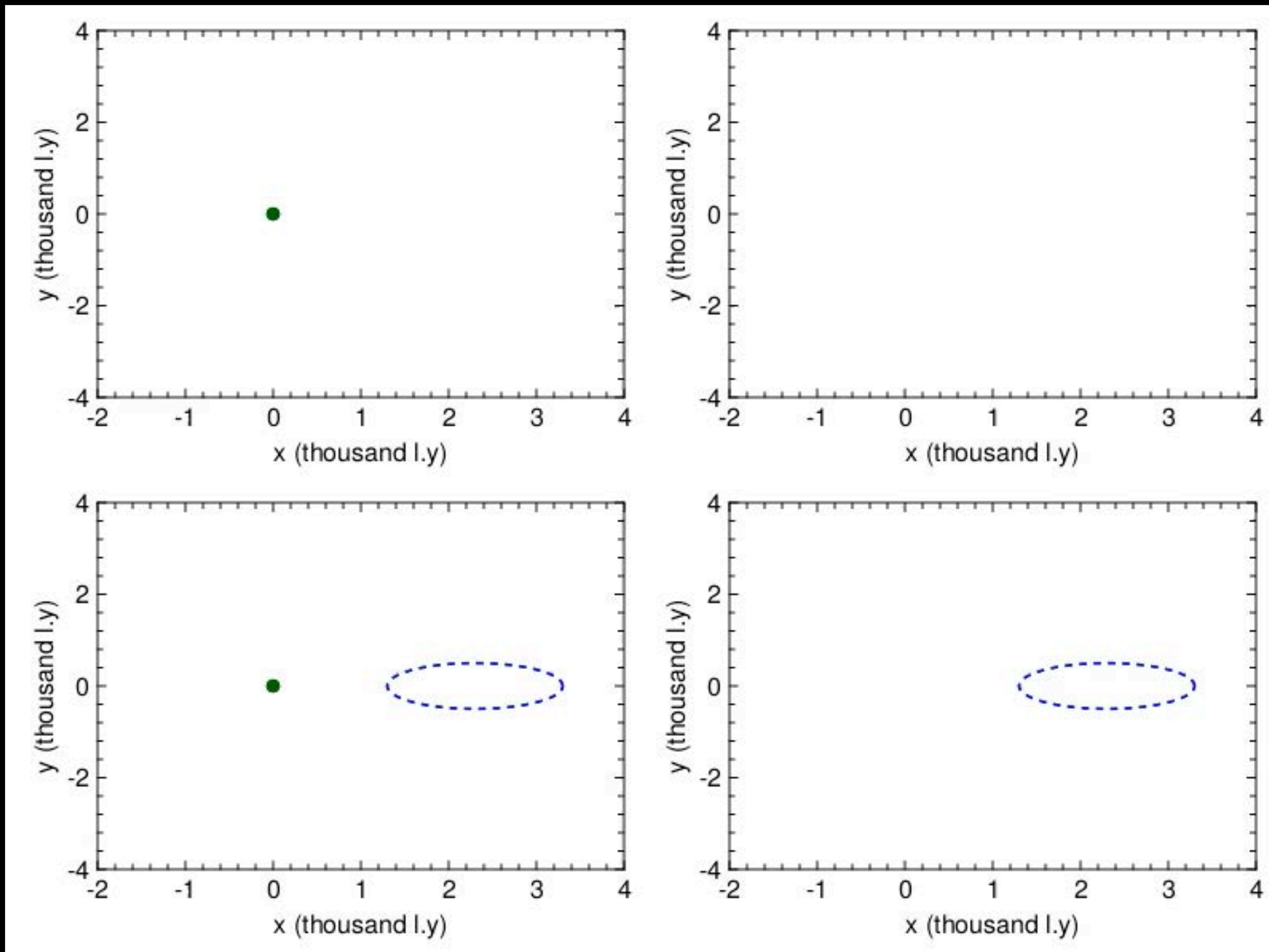
1632

Dynamical friction



Dynamical friction

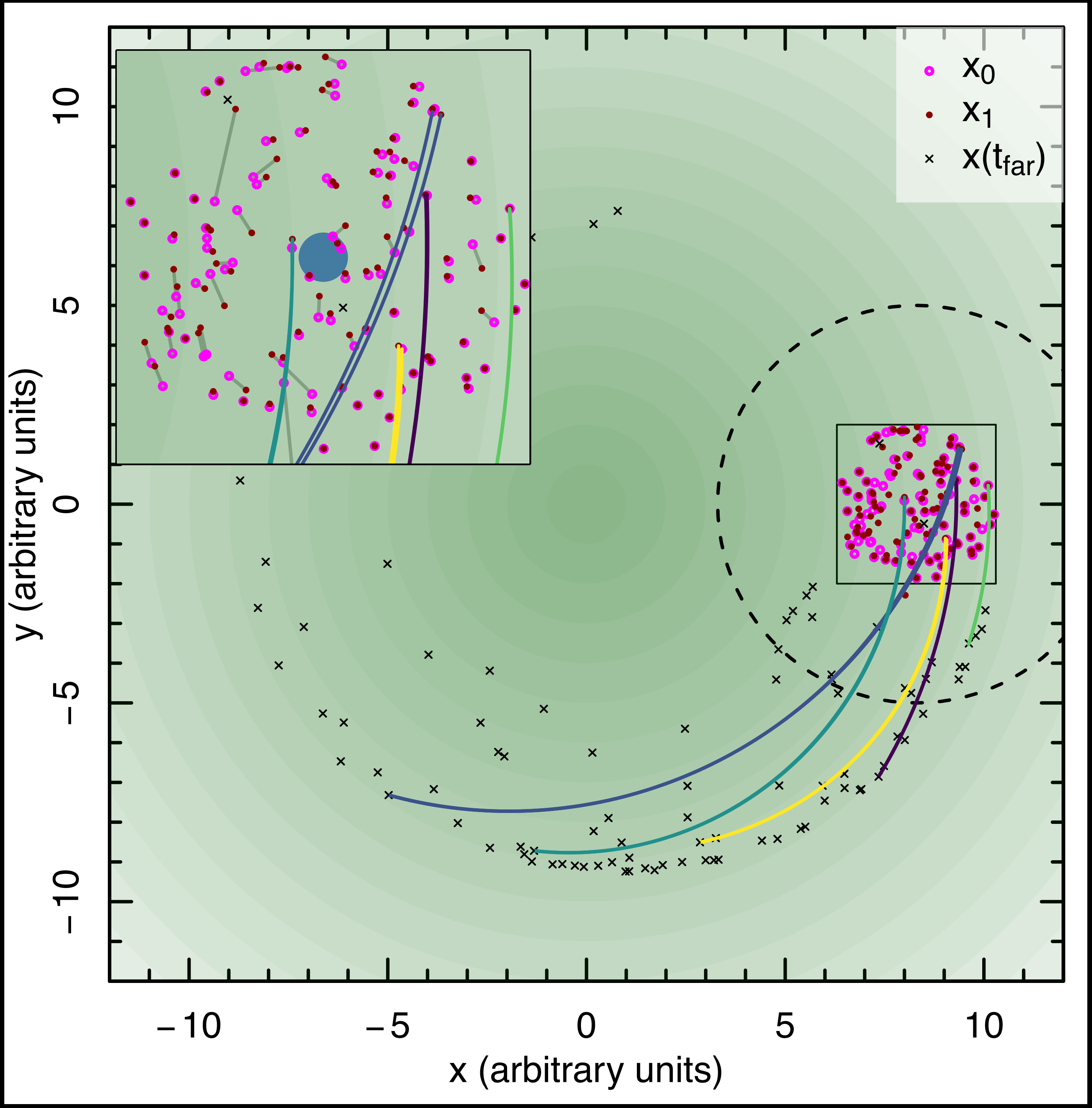


Illustration is heavily exaggerated

Orbit integration to past:

$$\dot{x} = v$$

$$\dot{v} = -\nabla(\Phi_{galaxy} + \Phi_{perturber})$$

Until the distance between the particle and perturber is so large we consider the perturber to give insignificant contribution to acceleration

Orbit integration back to the present:

$$\dot{x} = v$$

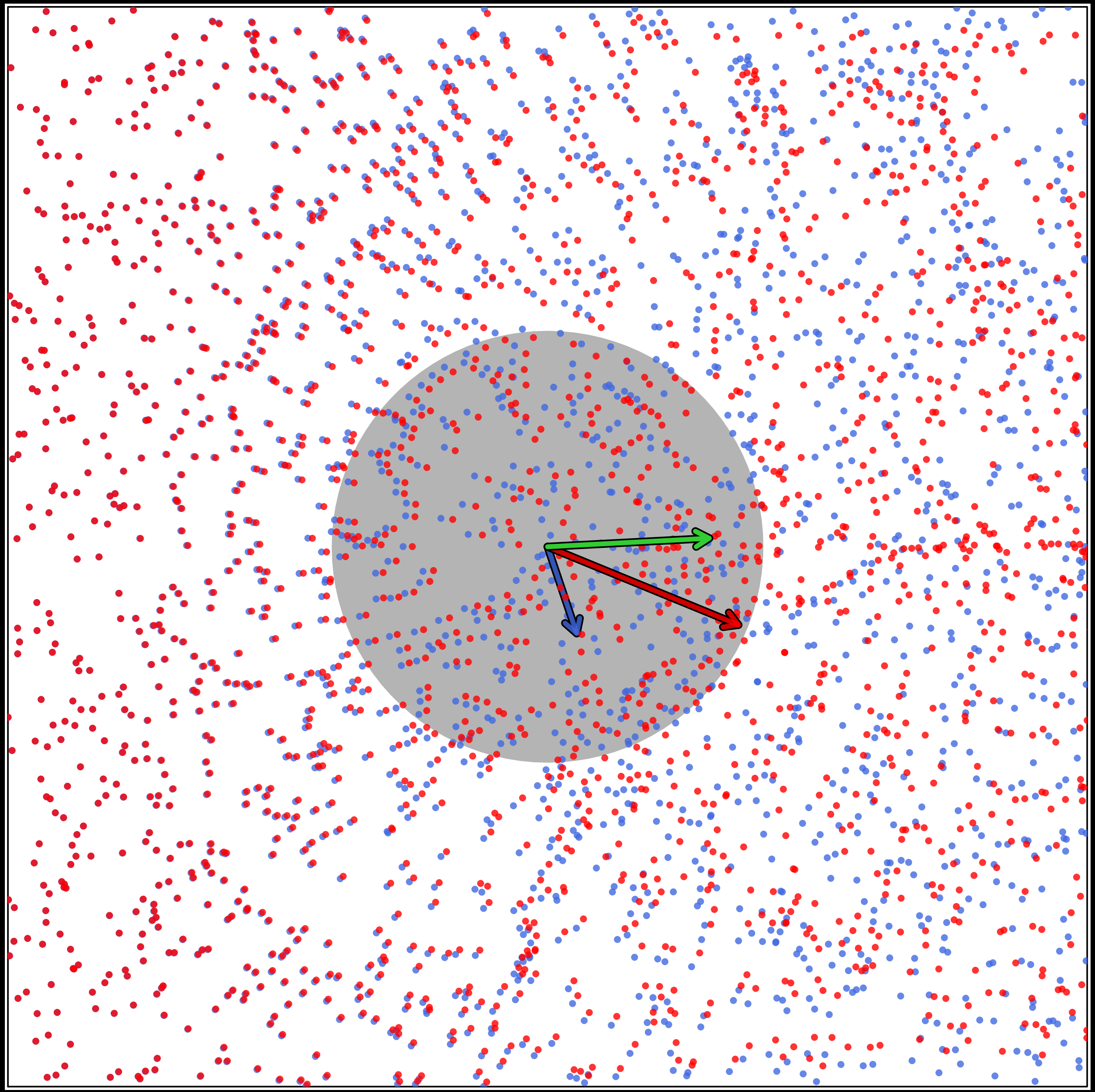
$$\dot{v} = -\nabla\Phi_{galaxy}$$

When applying this procedure repeatedly, we get 2 distributions around the GC:

- Density of perturbed state
- Density of unperturbed state

Their difference causes DF

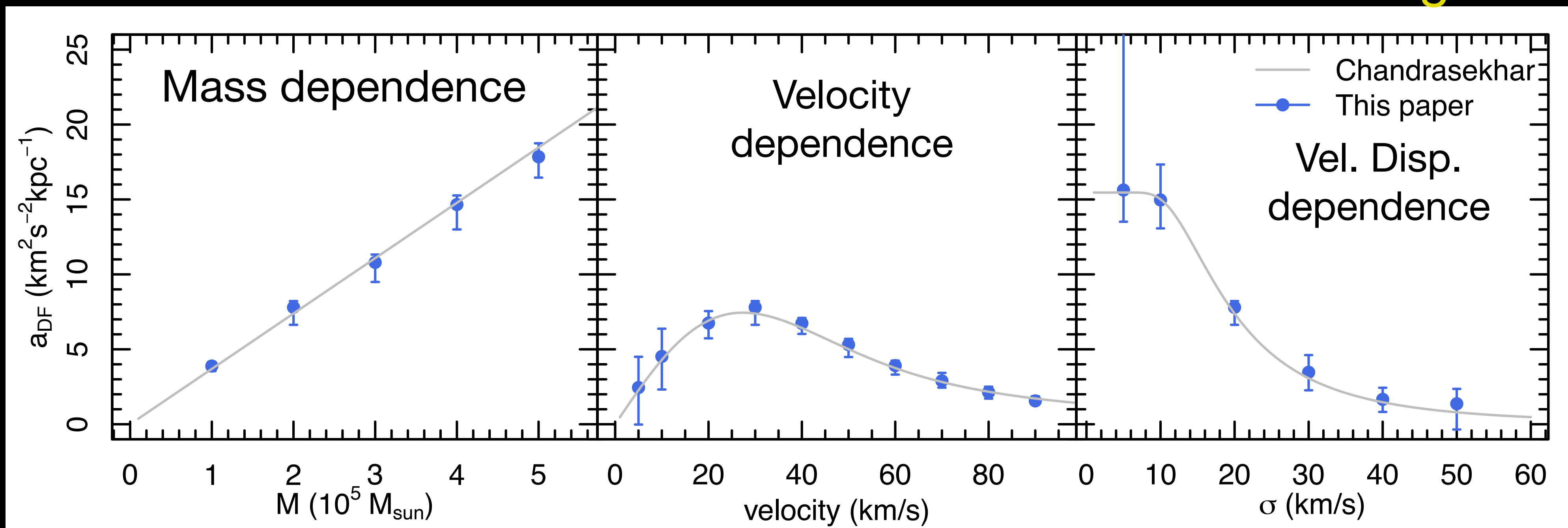
Dynamical friction

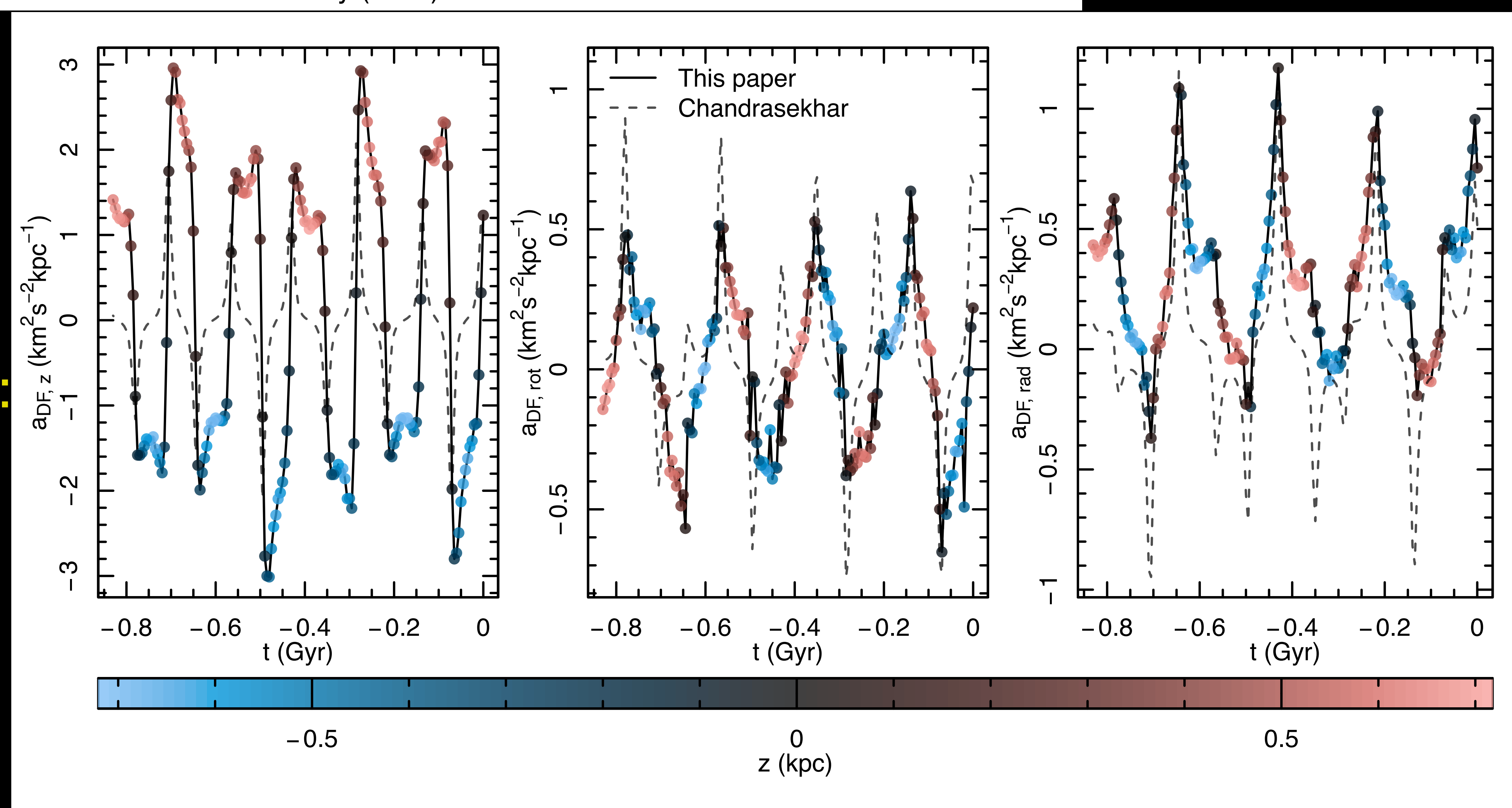


Dynamical friction (DF)   perturbed acceleration   unperturbed acceleration

Dynamical friction

Chandrasekhar method assumptio
Isotropic velocities
Homogeneous environment

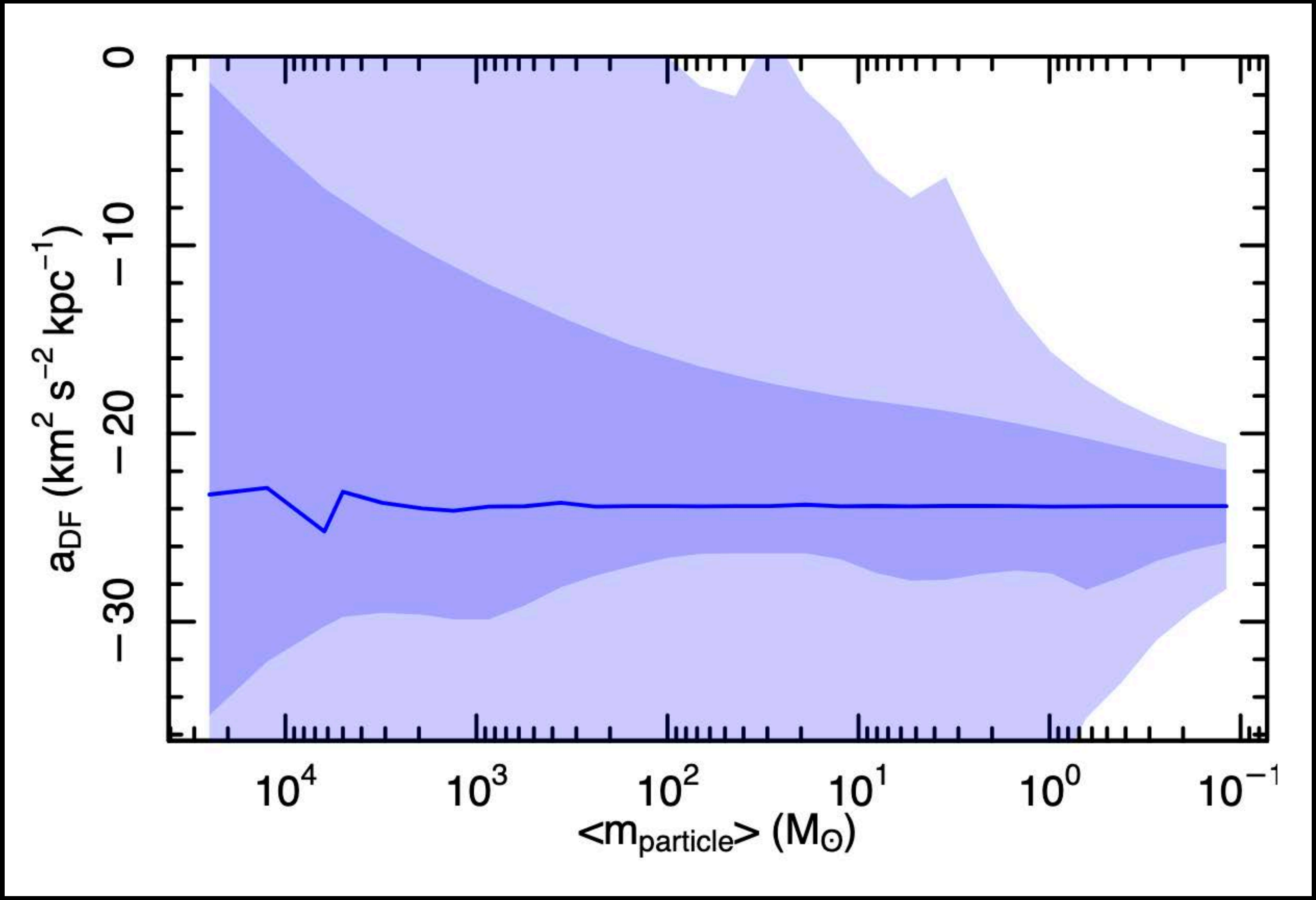




Chandrasekhar method assumptions:
Isotropic velocities
Homogeneous environment

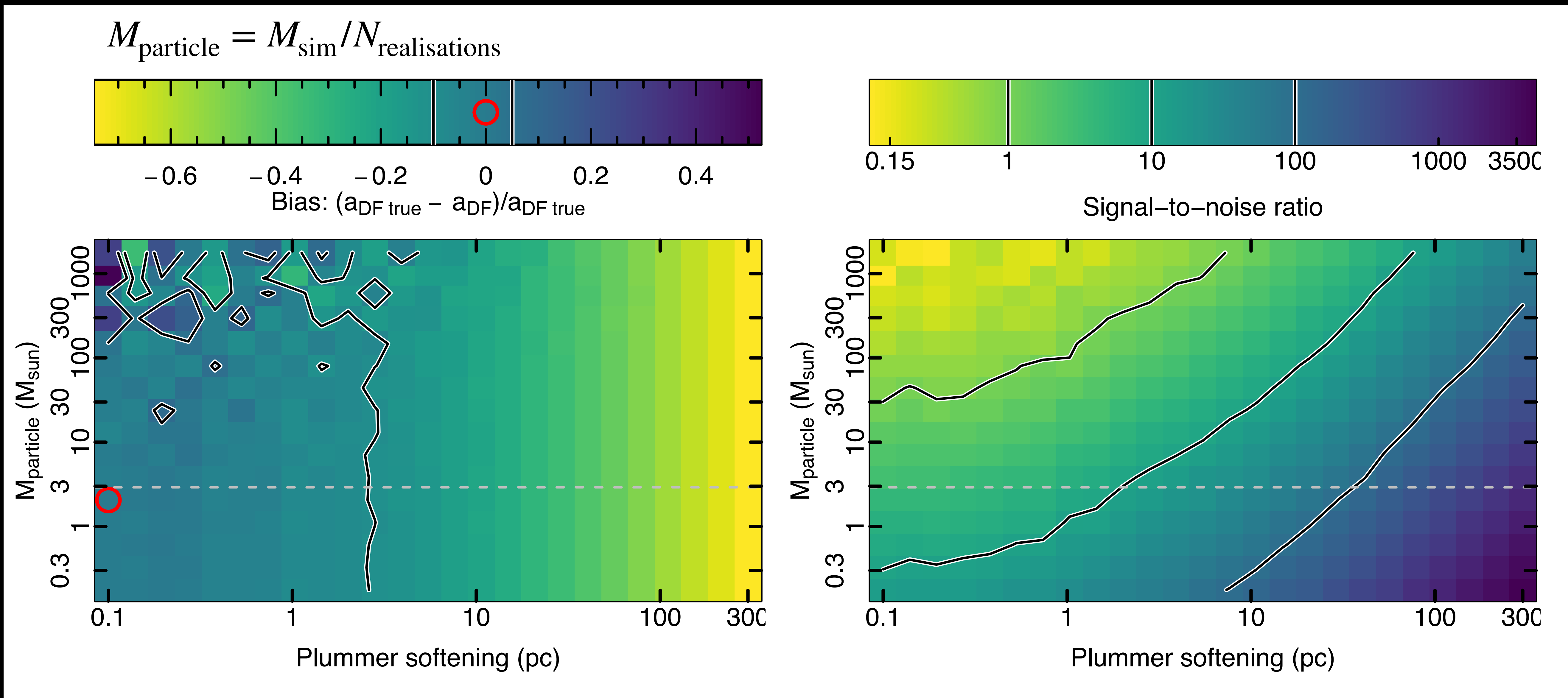
Dynamical friction

The dynamical friction for the SMBH is sometimes not resolvable in simulations, but here it is seen that it is physically always



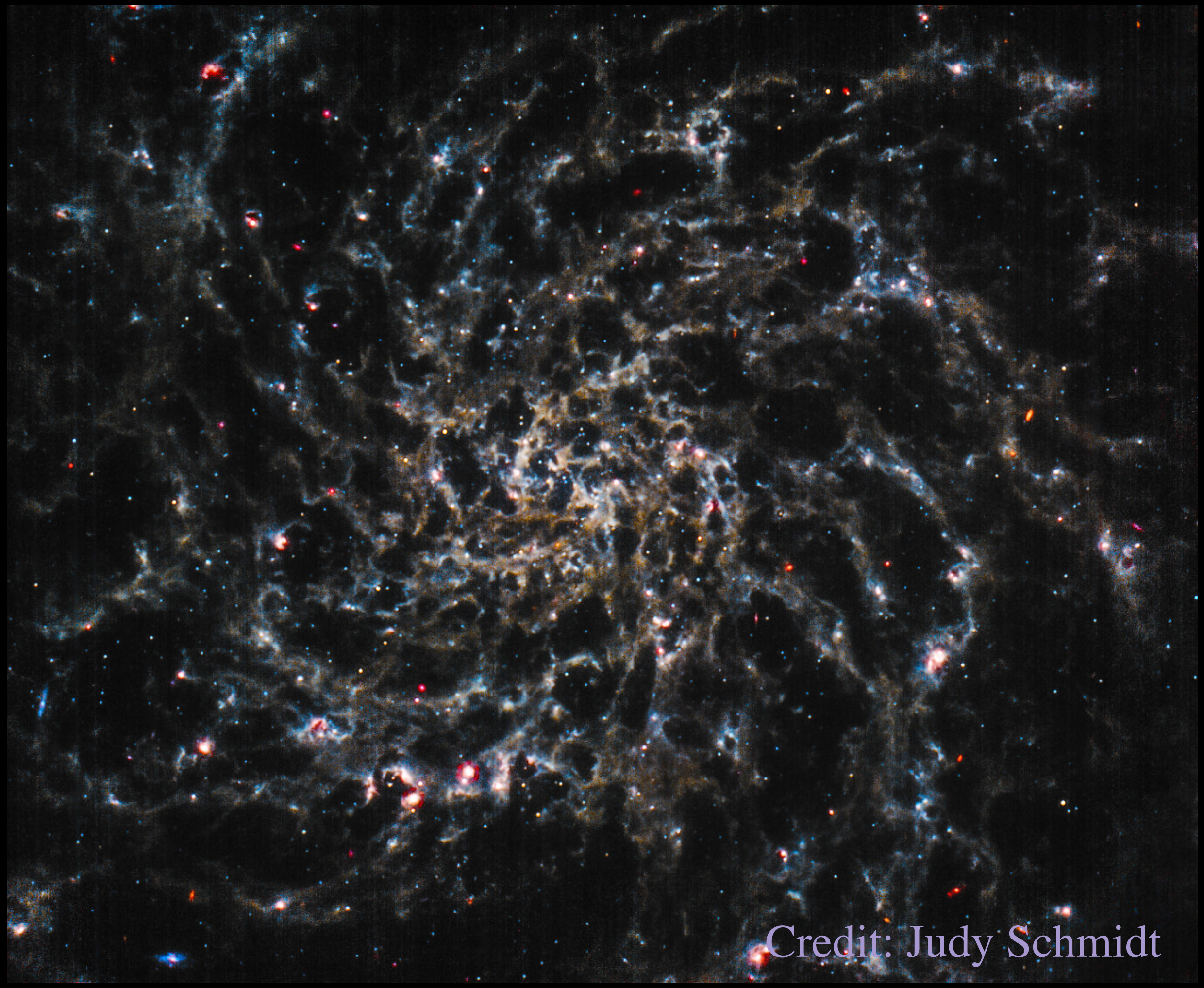
The mass of the perturber is $10^9\,M_\odot$

Dynamical friction

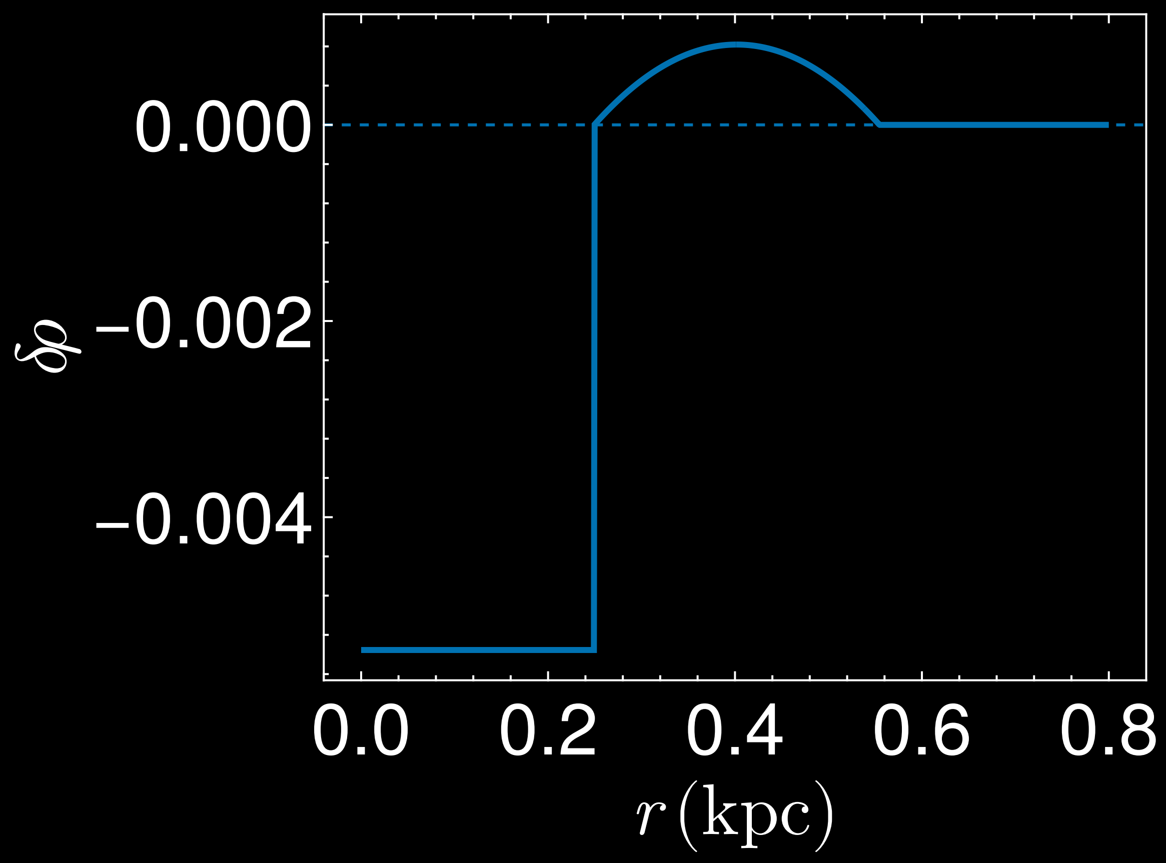


Superbubbles

Superbubbles are cavities caused by supernovae explosions that push out the gas from the vicinity of the open cluster where the SN originate.



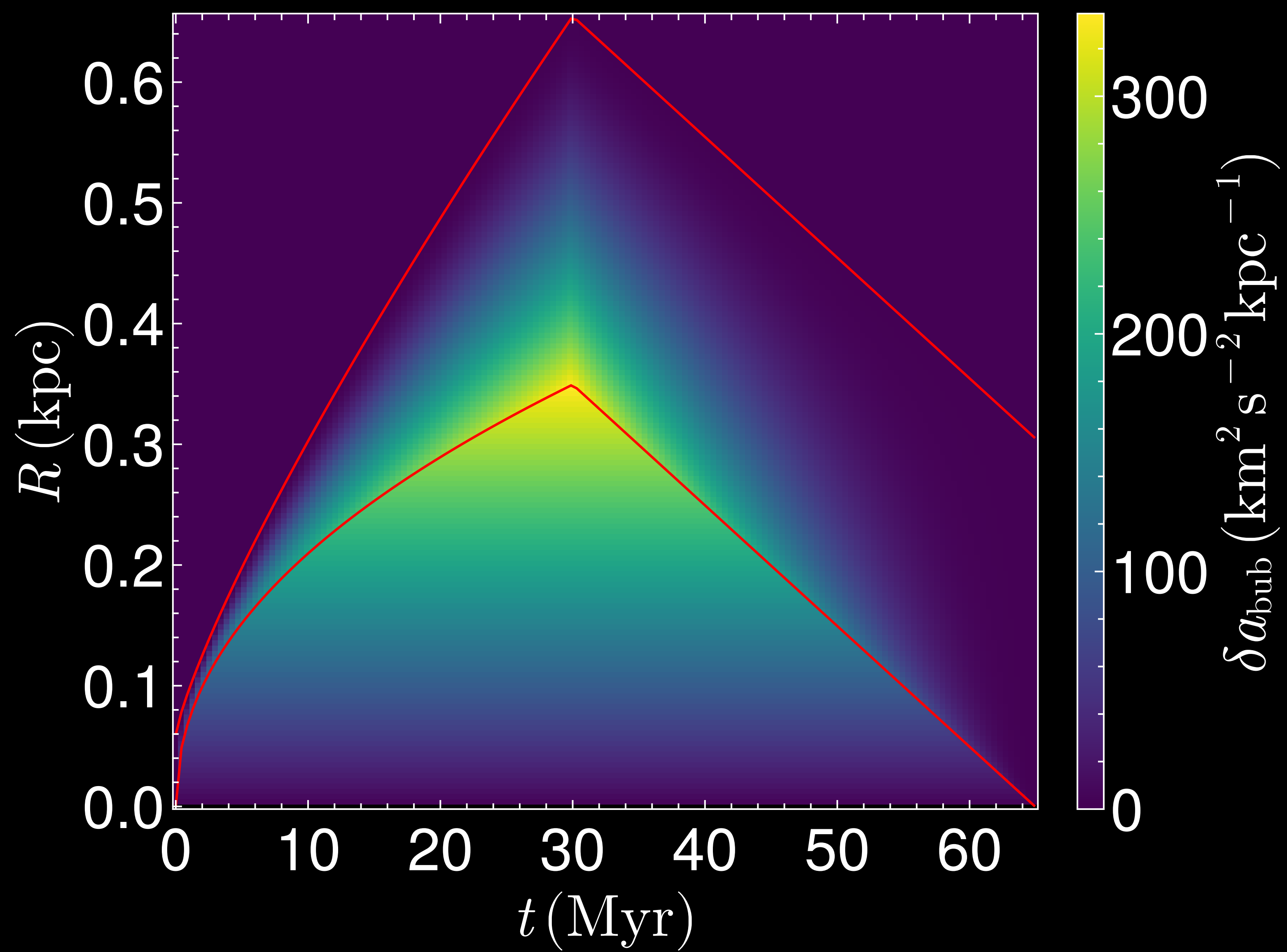
The density profile is inspired by Yadav et al. 2017 paper



Superbubbles

The unnatural aspects about superbubbles (SB):

- Acceleration of the SB has **no influence outside** of the SB
- SB changes relatively fast, comparable with $\sigma_\star$
- The acceleration correction is **directed outwards**

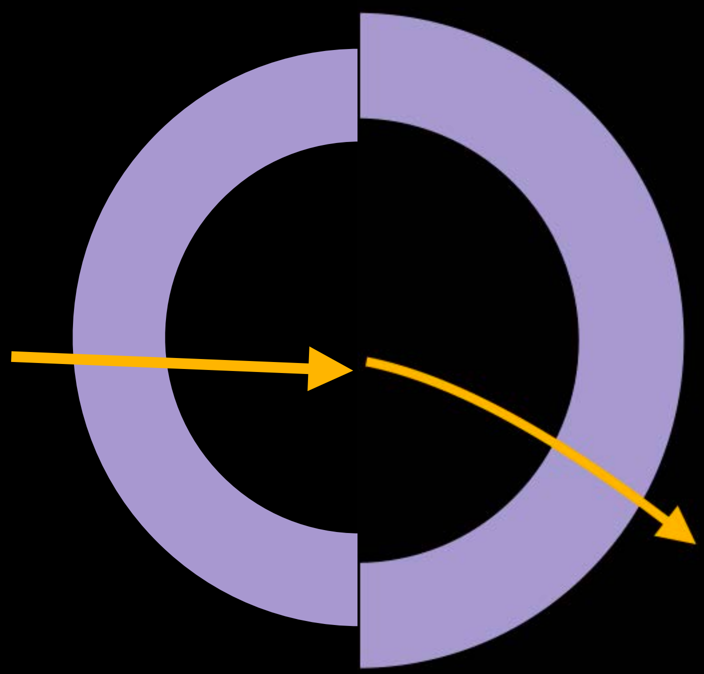


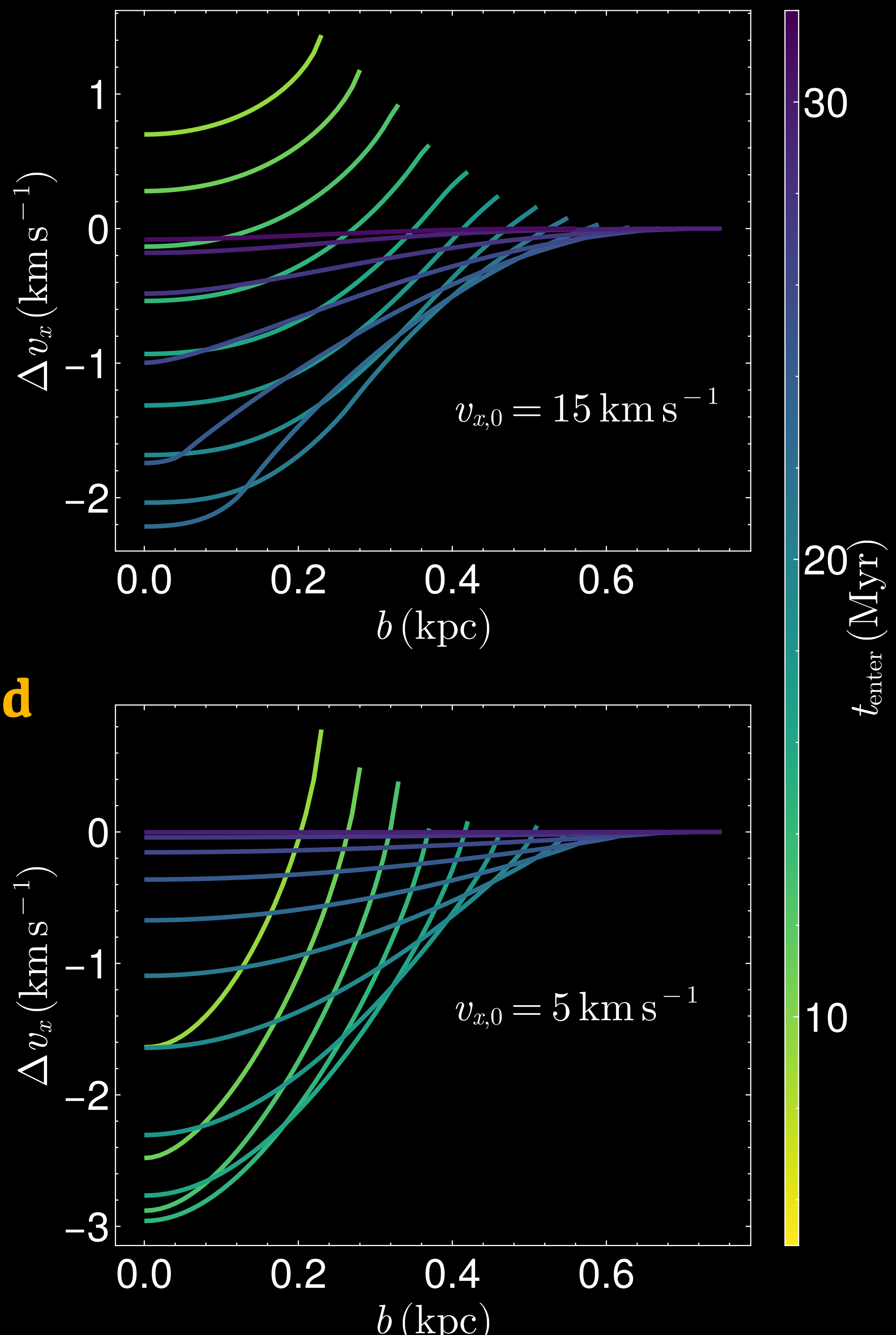
To apply the SB effects to the acceleration field we add it in the form of acceleration correction: $a = a_{\mathrm{host}} + \delta a_{\mathrm{bub}}$. The correction to acceleration originates from modelling simulation data:

$$\delta a_{\mathrm{bub}} = -\frac{G\delta M(r)}{r^2} = -\frac{G}{r^2}\int_0^r 4\pi R^2(\rho_{\mathrm{sim}}(R) - \rho_{\mathrm{env}}(R))\,\mathrm{d}R$$

A star passing through a SB

- Star enters the SB
- It de-accelerates until reaches centre
- SB has expanded
- Star accelerates after crossing centre-line
- It accelerates until exiting SB





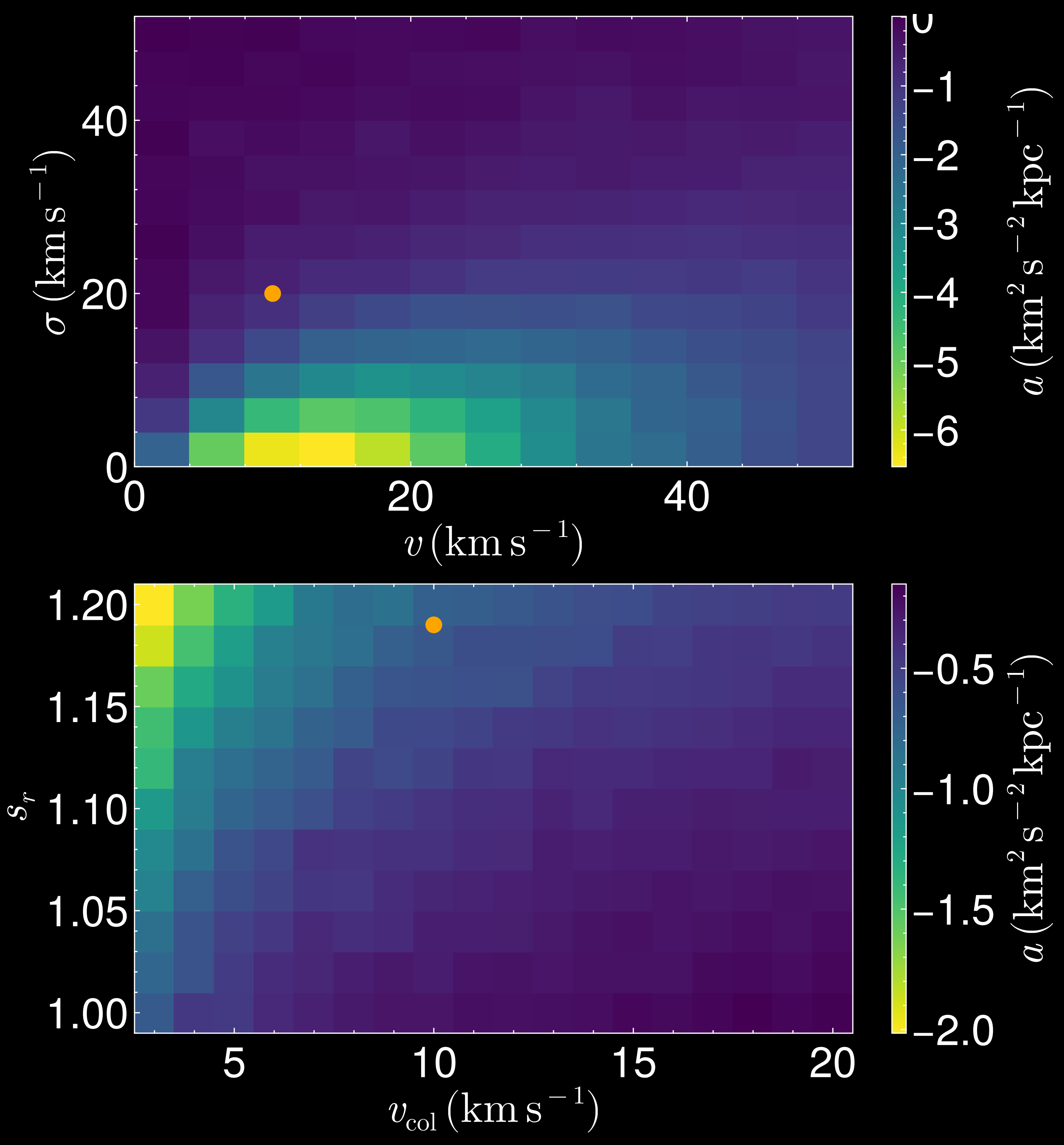
- **The SB size difference between entering and exiting determines net velocity gain**

- Very slow stars get turned around before exiting the SB.
- Upon entering the collapsing phase, the star probably de-accelerates.
- Upon entering and exiting in the expanding phase, star probably accelerates.

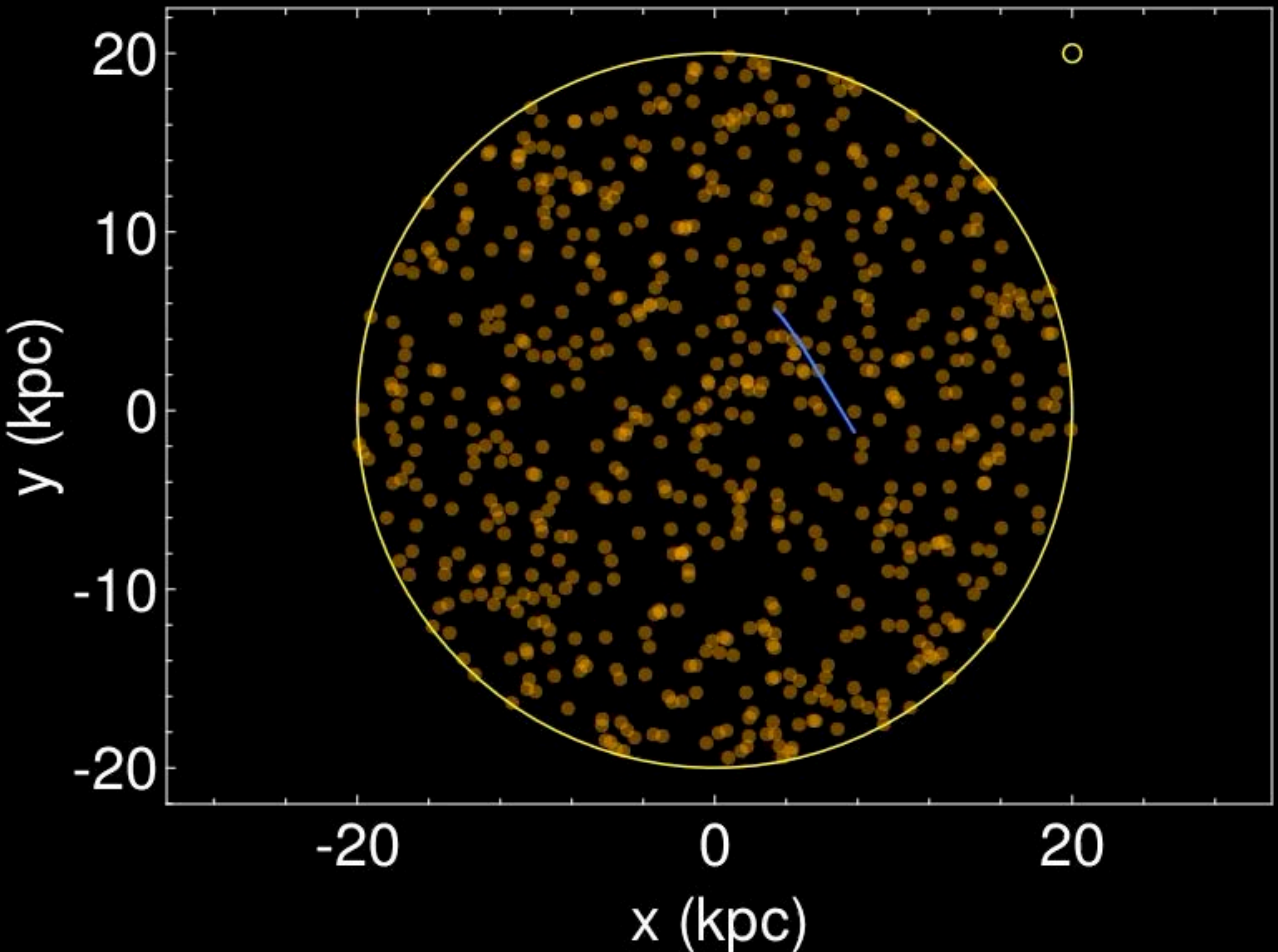
Superbubbles and gas disc

If the superbubbles appear and disappear continously, then there is a smooth transfer of angular momentum between stellar disc (or DM halo) and gas disc.

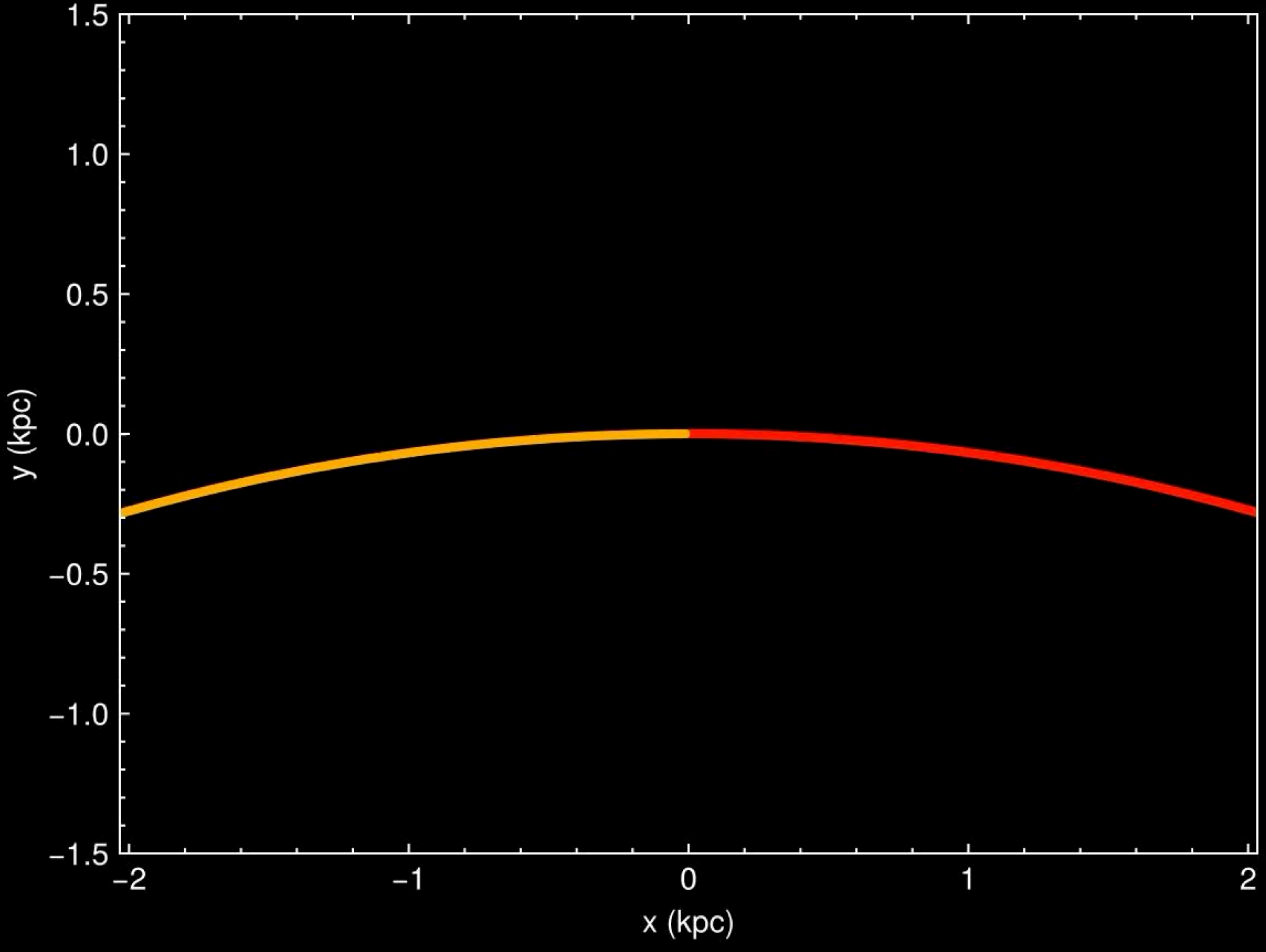
The precise amount depends on specifics on the galaxy, but friction on superbubbles may remove $\lesssim 40\,\%$ of the angular momentum throughout the age of galaxy. Turbulences are much more effective on driving gas disc evolution.



How would SB influence a stream?

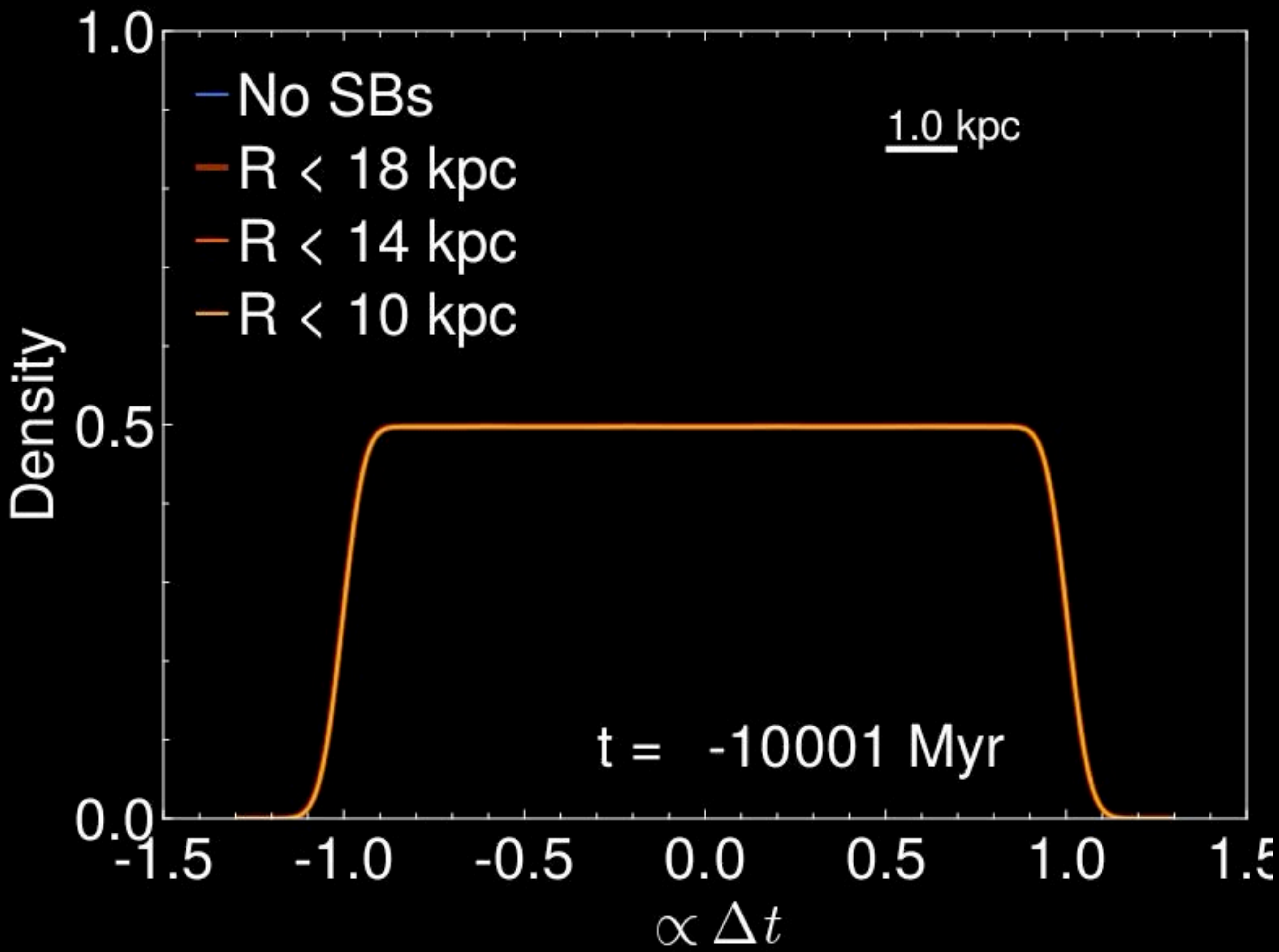


An encounter: stream and 1 SB

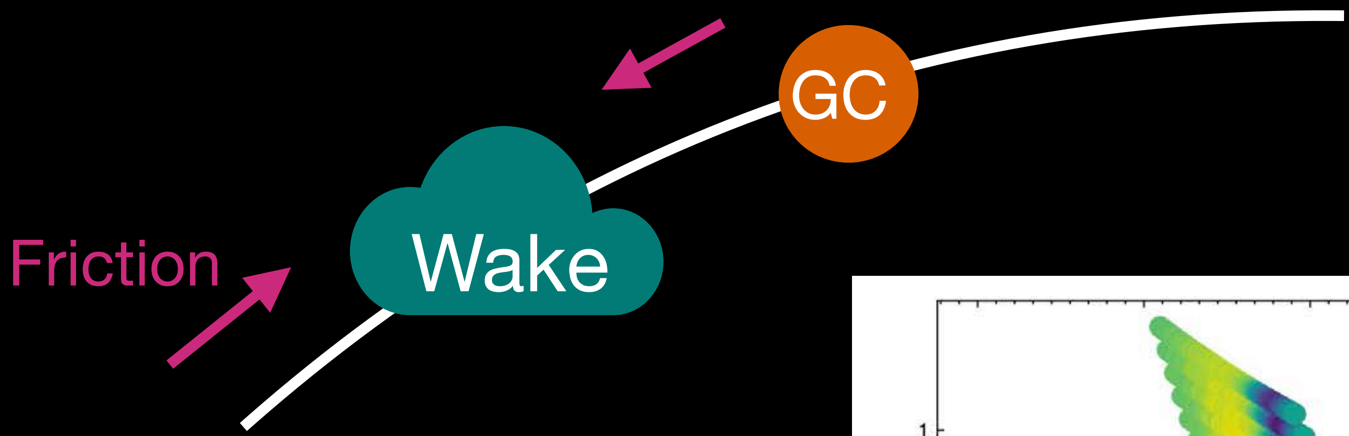


The net effect of the superbubbles

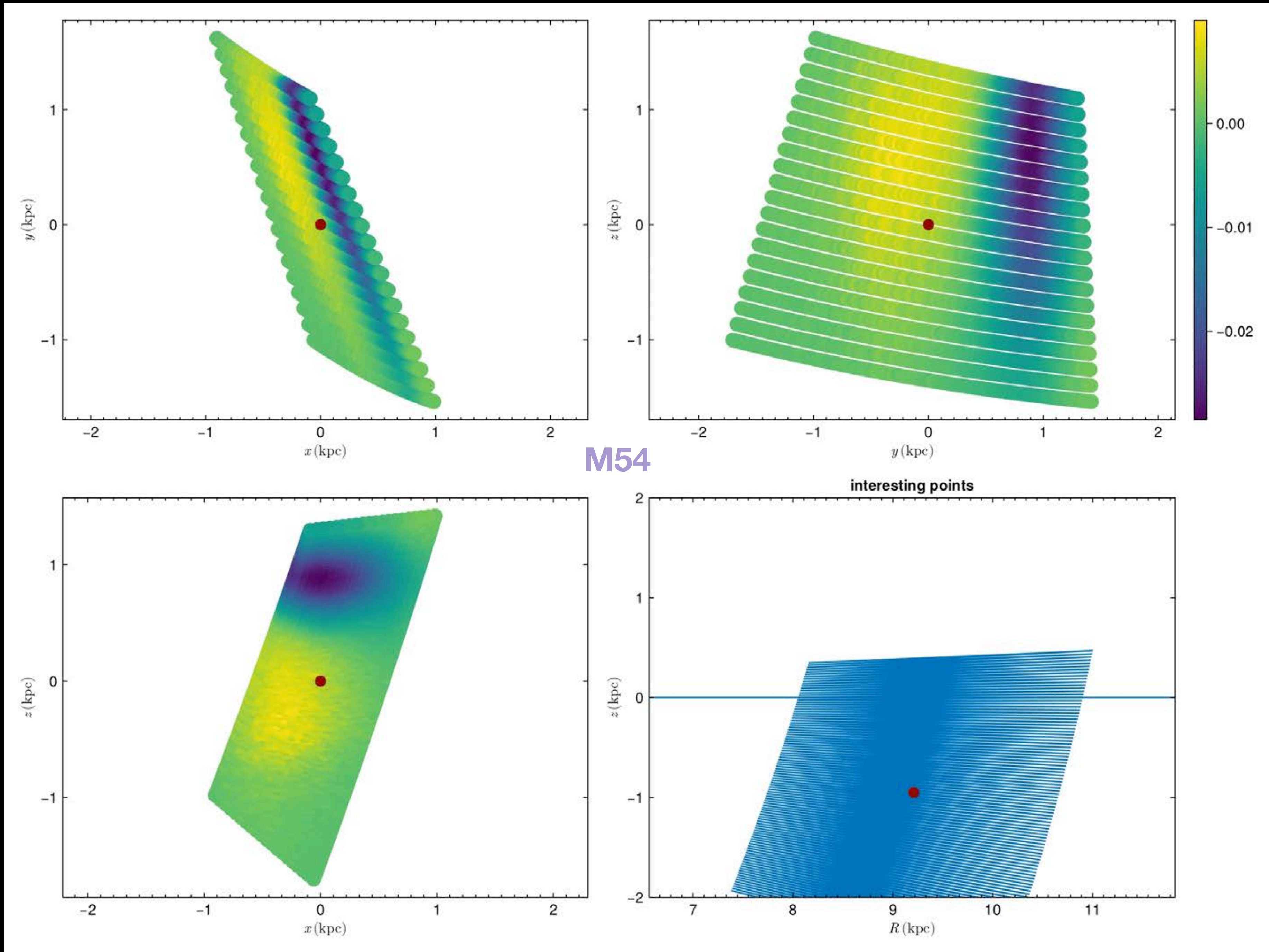
The cumulative effect of the superbubbles on the stream.



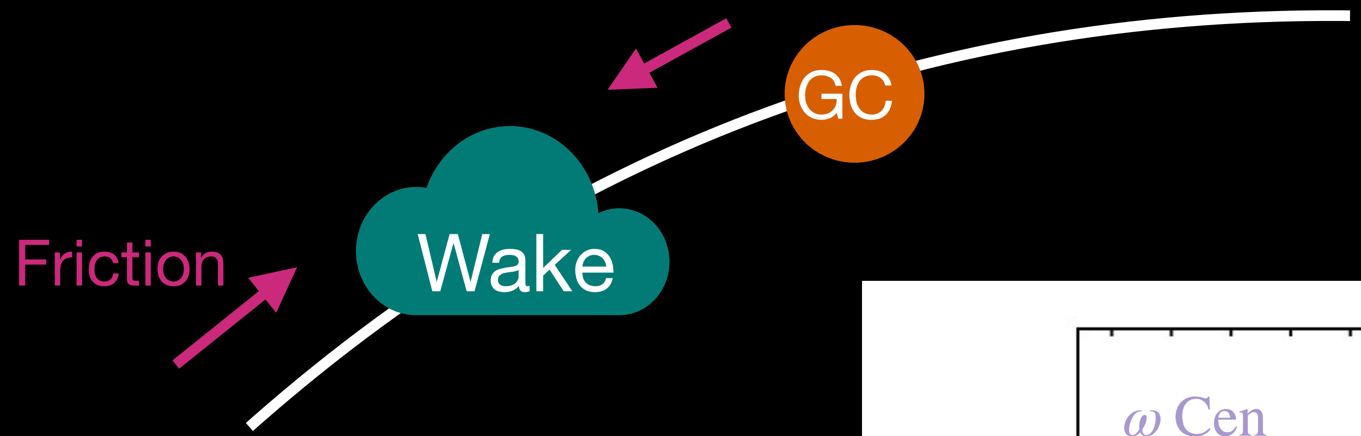
Stellar streams - friction

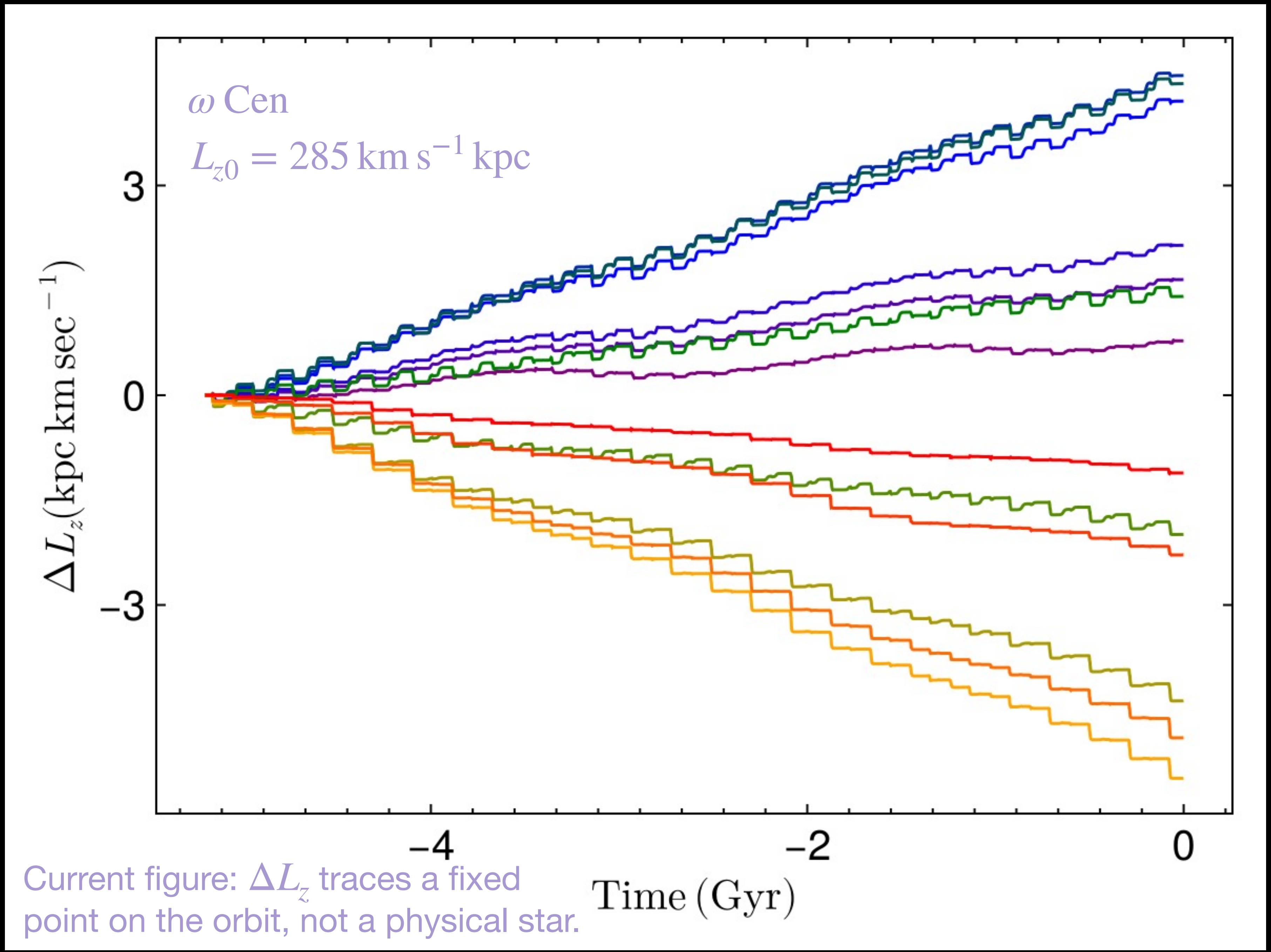


The wake that is caused by the DM does not influence the stream significantly, but passing stellar disc does it more.



Stellar streams - friction





Conclusions

2311.03790
2404.18086

- The tidal effects of dynamical friction may be calculated by integrating orbits back and forth.
- The friction from black holes is highly sensitive to noise and sampling, and even the physical density of Solar Neighbourhood leaves some scattering in the acceleration.
- The friction can somewhat change the outlook of the stream, where the wake is staying on.
- Superbubbles can create gaps and ridges in the stellar streams
- Superbubbles can cause minimal, but still existent secular evoution of the gas disc.