PARTICLE TAGGING AND ITS IMPLICATIONS FOR STELLAR POPULATION DYNAMICS

Theo Le Bret, A. Pontzen, A. Cooper, C. Frenk and A. Zolotov, A. Brooks, F. Governato, O. Parry.

February 26, 2015

Institute for Theoretical Physics, Oxford University

"Galactic Archeology":

· Fossils of hierarchical galaxy formation

Challenges for simulators:

Stellar Haloes

"Galactic Archeology":

· Fossils of hierarchical galaxy formation

· Low densities, so "retain memory"

Challenges for simulators:

"Galactic Archeology":

· Fossils of hierarchical galaxy formation

· Low densities, so "retain memory"

· Stellar streams trace accretion history

Challenges for simulators:

Stellar Haloes

"Galactic Archeology":

· Fossils of hierarchical galaxy formation

· Low densities, so "retain memory"

· Stellar streams trace accretion history

Challenges for simulators:

· Stochastic, so need to simulate lots of them

Stellar Haloes

"Galactic Archeology":

· Fossils of hierarchical galaxy formation

· Low densities, so "retain memory"

· Stellar streams trace accretion history

Challenges for simulators:

· Stochastic, so need to simulate lots of them

· But means fewer simulation particles there

Stellar Haloes

"Galactic Archeology":

· Fossils of hierarchical galaxy formation

· Low densities, so "retain memory"

· Stellar streams trace accretion history

Challenges for simulators:

· Stochastic, so need to simulate lots of them

· But means fewer simulation particles there

· But they are hard to resolve in a simulation

Stellar Haloes

"Galactic Archeology":

- Fossils of hierarchical galaxy formation
- Low densities, so "retain memory"
- Stellar streams trace accretion history

Challenges for simulators:

- Stochastic, so need to simulate lots of them
- But means fewer simulation particles there
- But they are hard to resolve in a simulation

- Need large numbers of high resolution, fully cosmological simulations. Very expensive if you include gas and stars!

Stellar Haloes

"Galactic Archeology":

· Fossils of hierarchical galaxy formation

· Low densities, so "retain memory"

· Stellar streams trace accretion history

Challenges for simulators:

· Stochastic, so need to simulate lots of them

· But means fewer simulation particles there

· But they are hard to resolve in a simulation

· Need large numbers of high resolution, fully cosmological simulations. Very expensive if you include gas and stars!

· So can we get a stellar halo without simulating stars?

How to paint stars onto Dark Matter particles in an N-body simulation(see Cooper et al 2010):

· Take snapshot of Dark-Matter only simulation
· In each halo, select the "most-bound" particles
· Assign these a stellar mass (use e.g. semi-analytic models)
· Evolve for one simulation time-step. Repeat.

At z=0, you have a stellar halo (ish).

Controversial assumptions:

· Recently formed stars and DM particles deep in their halo's potential well have similar kinematics
· Binding energy is a good enough proxy for the full phase space information
· Baryons are unimportant for stellar halo formation

(And no in situ, but that's another story! See Font et al, 2011.)

The controversy (Bailin et al, 2014):
"Given this level of systematic uncertainty, one should be wary of overinterpreting differences between observations and the current generation of stellar halo models based on dark matter only simulation s when such differences are less than an order of magnitude."

Need a controlled comparison between tagging and SPH!

Particle Tagging: comparing with SPH

3 schemes to compare:

1. Stars in a full SPH
2. Tagged DM in (the same) SPH
3. Tagged DM in a collisionless simulation

· Form the basis of comparison
· Investigate differences in stars and DM kinematics
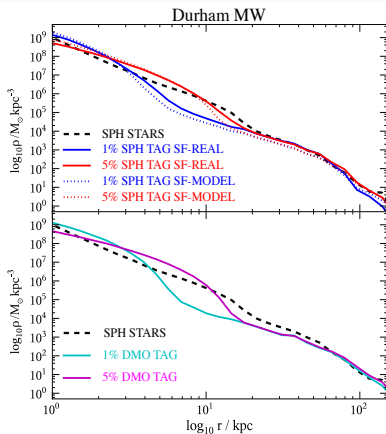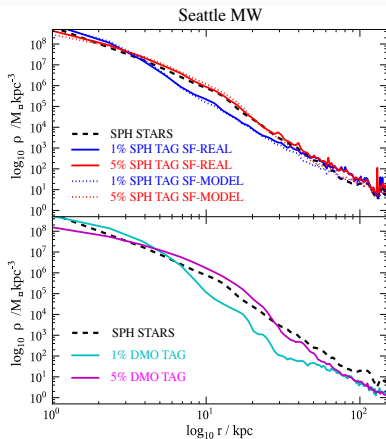· Investigate role of baryonic effects

Did this for two sets of DMO and SPH simulations to investigate role of feedback in establishing comparison:

· Durham simulations (Parry +, 2012), "Passive" feedback
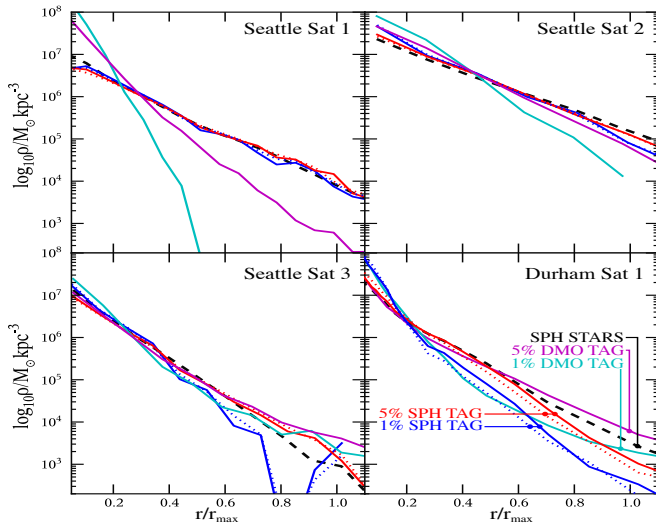· Seattle simulations(Zolotov +, 2009), "Active", bursty feedback
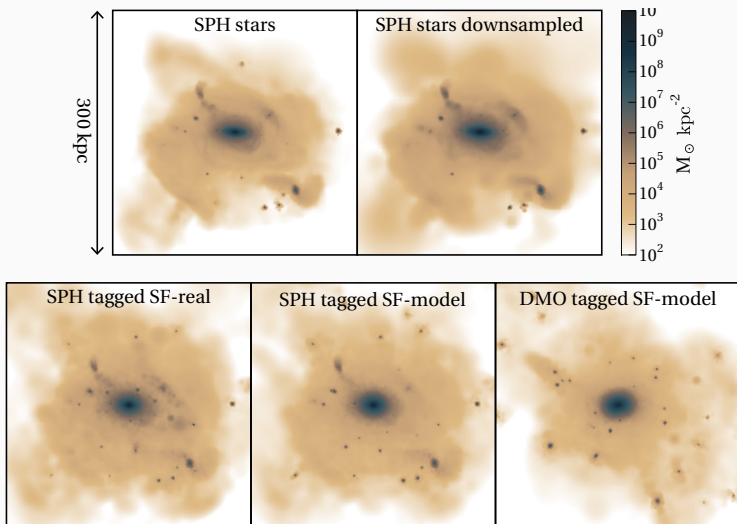
How does changing the most-bound fraction and/or the type of feedback affect our comparison between SPH and tagging?

· Tagging 1 or 5 % doesn't change much in Seattle SPH

-> Investigate how a single stellar population and its tagged analogues evolve.

How does changing the most-bound fraction and/or the type of feedback affect our comparison between SPH and tagging?

· Tagging 1 or 5 % doesn't change much in Seattle SPH
· But it does in Durham SPH!

-> Investigate how a single stellar population and its tagged analogues evolve.

How does changing the most-bound fraction and/or the type of feedback affect our comparison between SPH and tagging?

· Tagging 1 or 5 % doesn't change much in Seattle SPH
· But it does in Durham SPH!
· Feedback is important.

-> Investigate how a single stellar population and its tagged analogues evolve.

How does changing the most-bound fraction and/or the type of feedback affect our comparison between SPH and tagging?

· Tagging 1 or 5 % doesn't change much in Seattle SPH
· But it does in Durham SPH!
· Feedback is important.
· Tagging 5% in DMO case is usually better

-> Investigate how a single stellar population and its tagged analogues evolve.

How does changing the most-bound fraction and/or the type of feedback affect our comparison between SPH and tagging?

· Tagging 1 or 5 % doesn't change much in Seattle SPH
· But it does in Durham SPH!
· Feedback is important.
· Tagging 5% in DMO case is usually better
· But fails miserably in Seattle Sat 1. Why?

-> Investigate how a single stellar population and its tagged analogues evolve.

How does changing the most-bound fraction and/or the type of feedback affect our comparison between SPH and tagging?

· Tagging 1 or 5 % doesn't change much in Seattle SPH
· But it does in Durham SPH!
· Feedback is important and double-edged!.
· Tagging 5% in DMO case is usually better
· But fails miserably in Seattle Sat 1. Why?

-> Investigate how a single stellar population and its tagged analogues evolve.
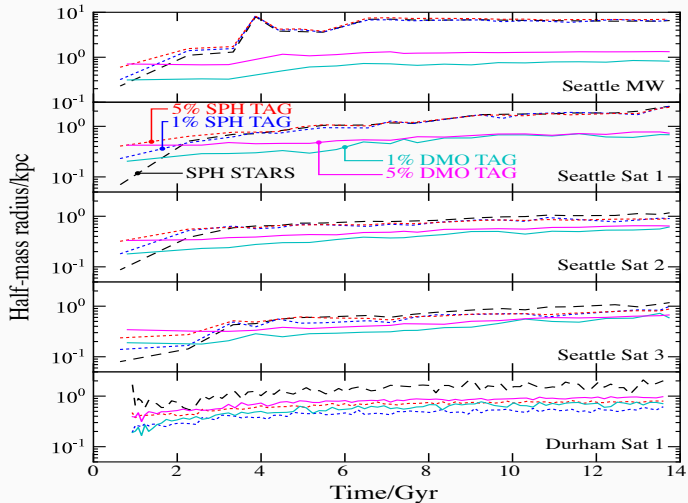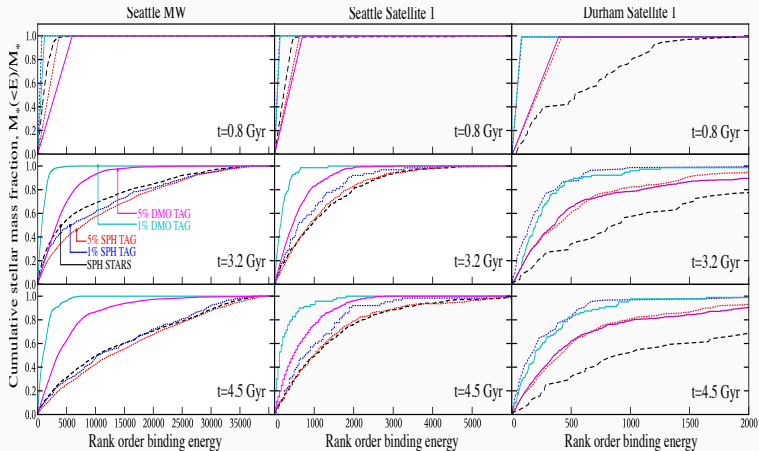
The validity of particle tagging hinges crucially on diffusion being taken into account (Le Bret +, submitted!):

· Low sensitivity to initial choice of tagged fraction
· Smooths out initial differences in dynamics

Things to keep in mind when tagging:

· At a minimum, use 'live' tagging schemes if tagging a fixed fraction
· And tag larger fraction which won't reflect where stars form but where they end up
· Need to better understand role of diffusion, e.g. how large the contribution from cored satellites to the halo is