UNIVERSITEIT GENT

Advanced methods in N-body/hydrodynamical simulations

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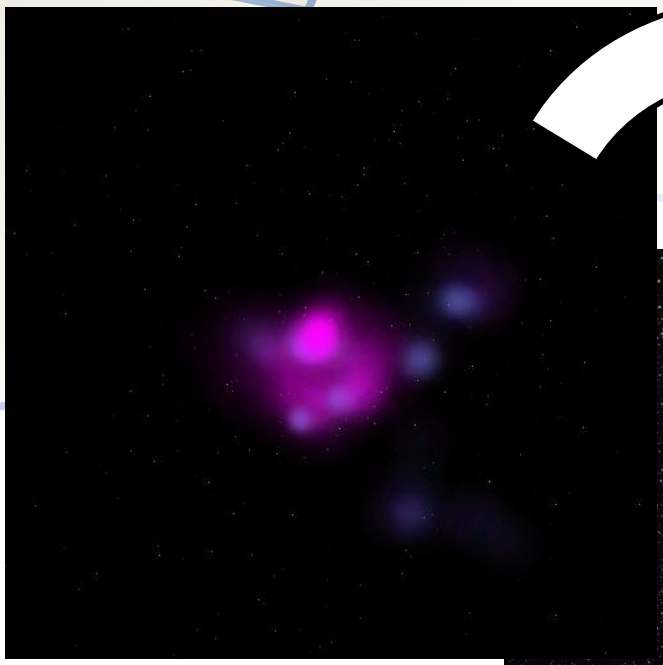
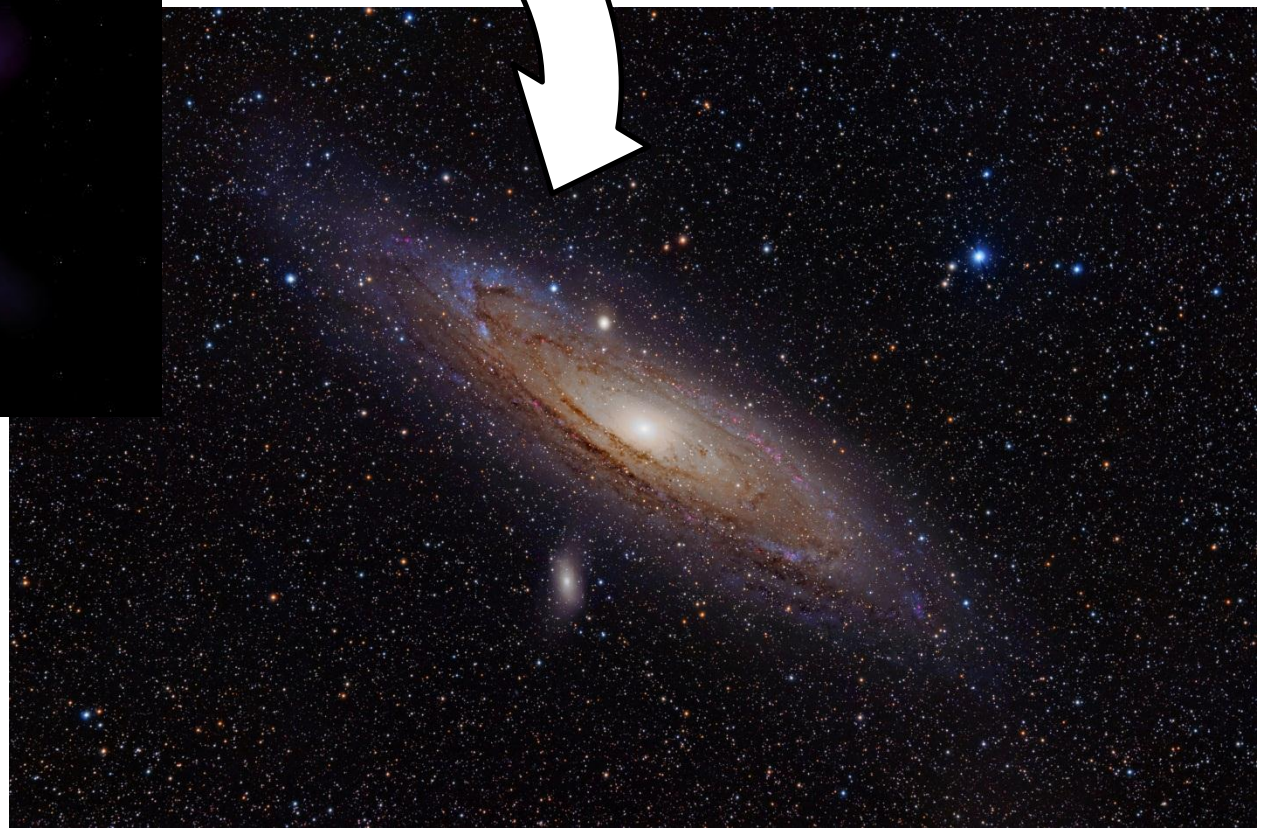
Introduction

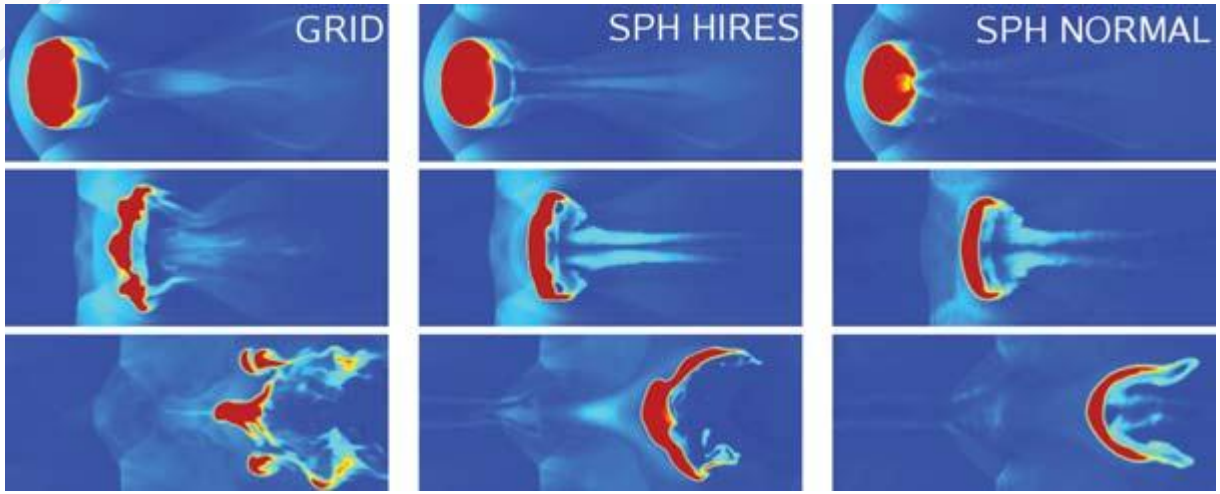


Ram pressure stripping



Hydrodynamics

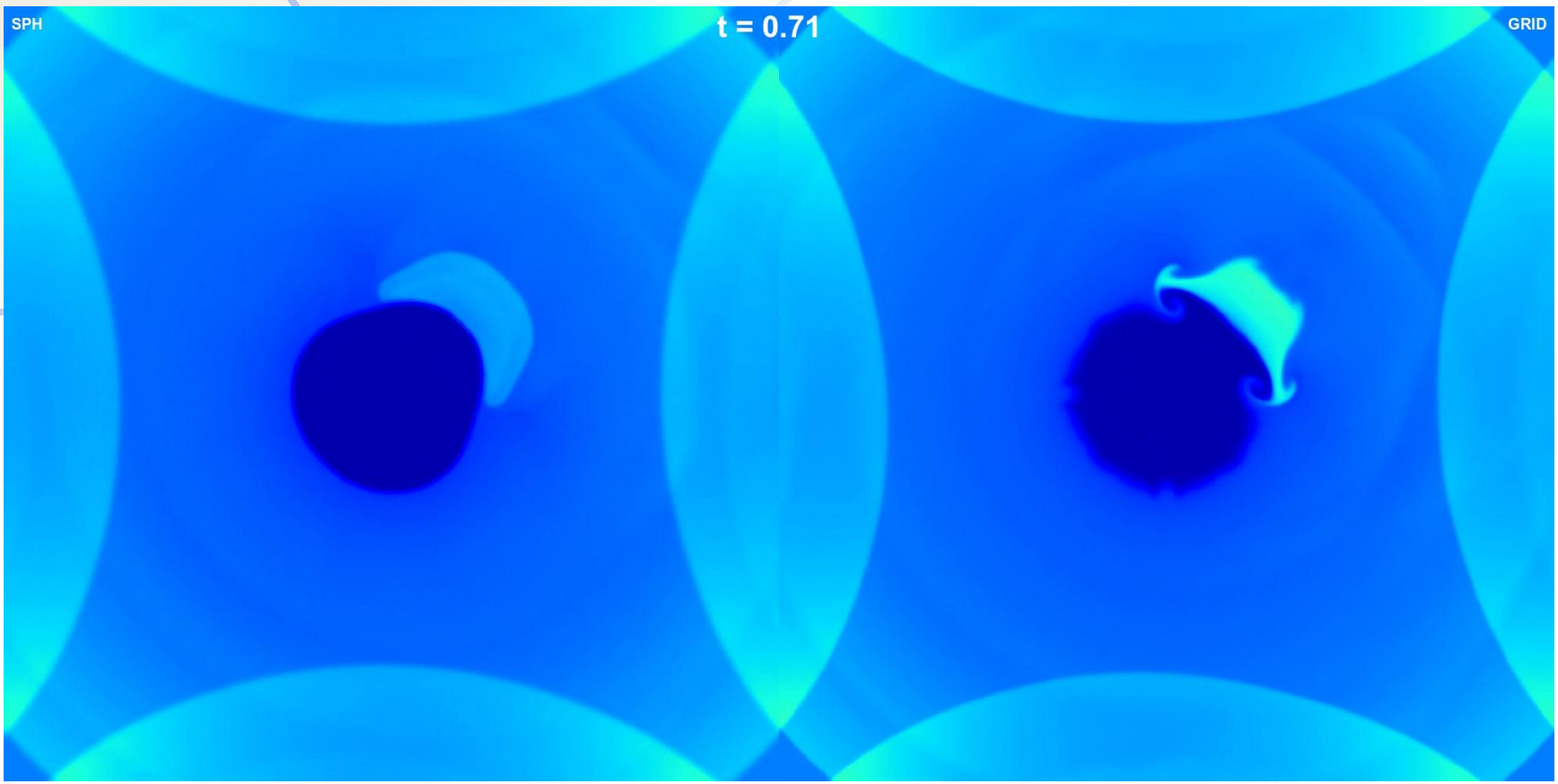
Blob test



Agertz et al. 2007

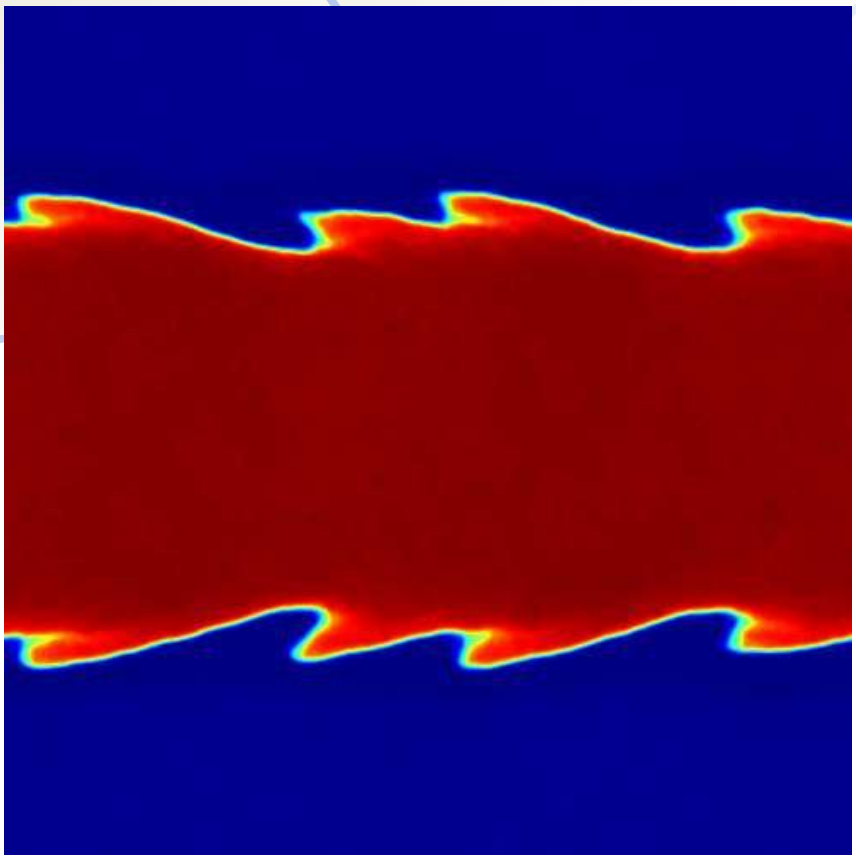
Instabilities

Gadget2 RAMSES

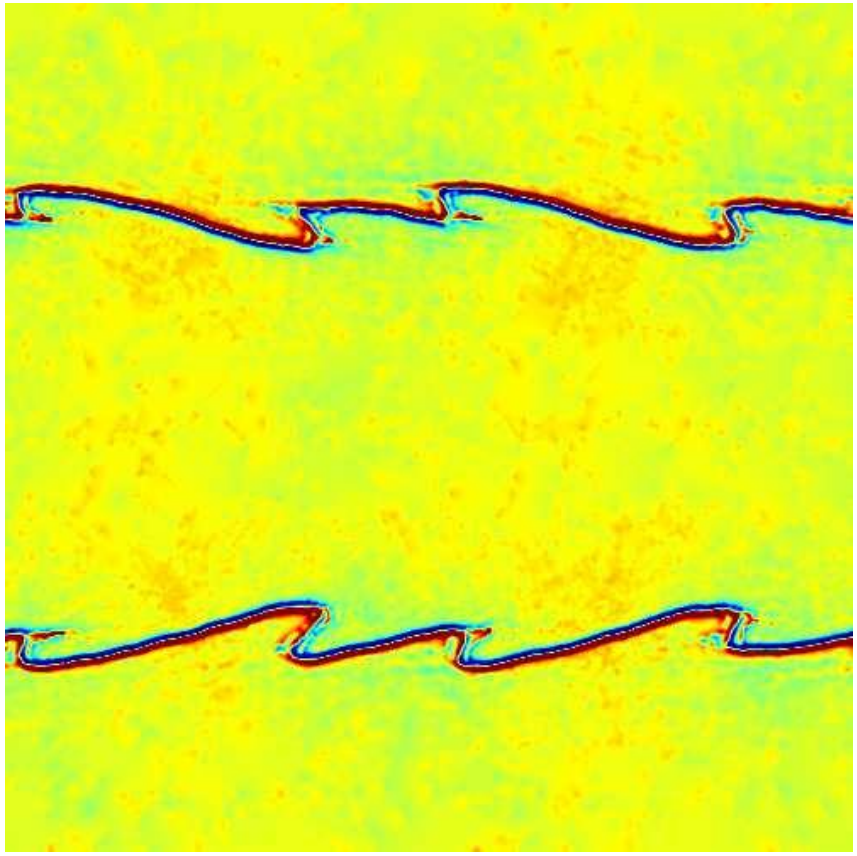


Artificial surface tension

Density

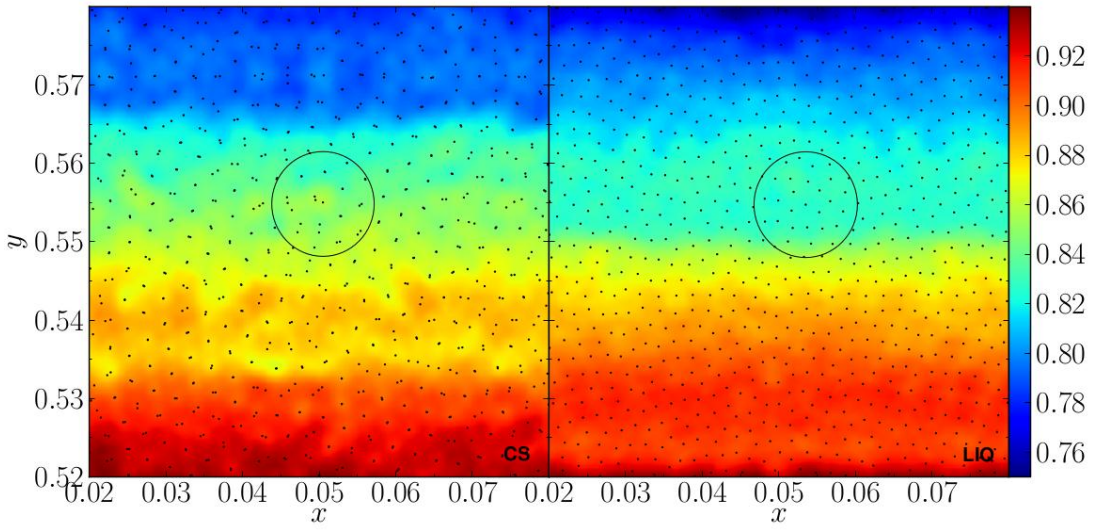


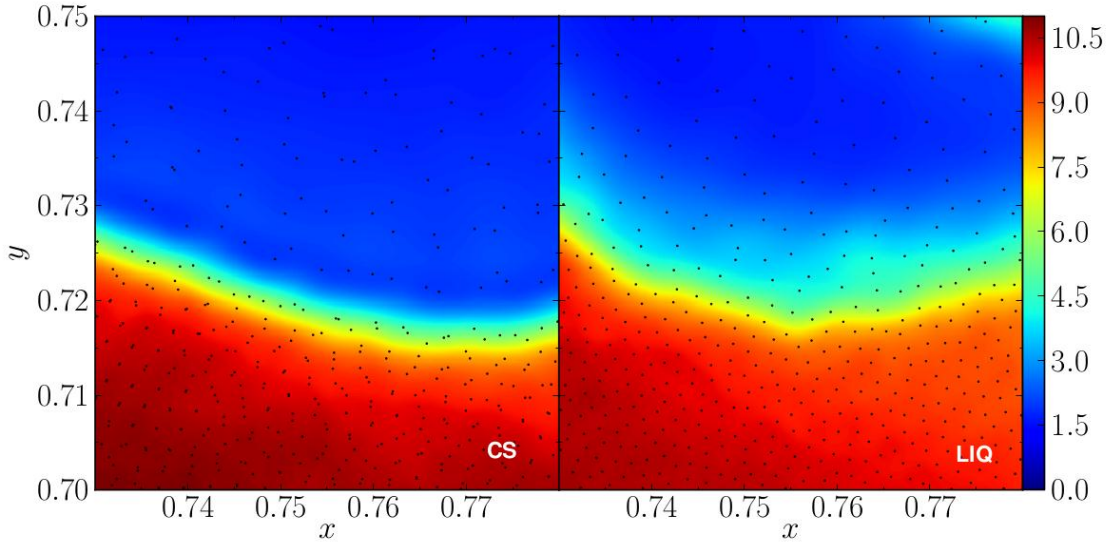
Pressure



Price 2008

Kernel smoothing



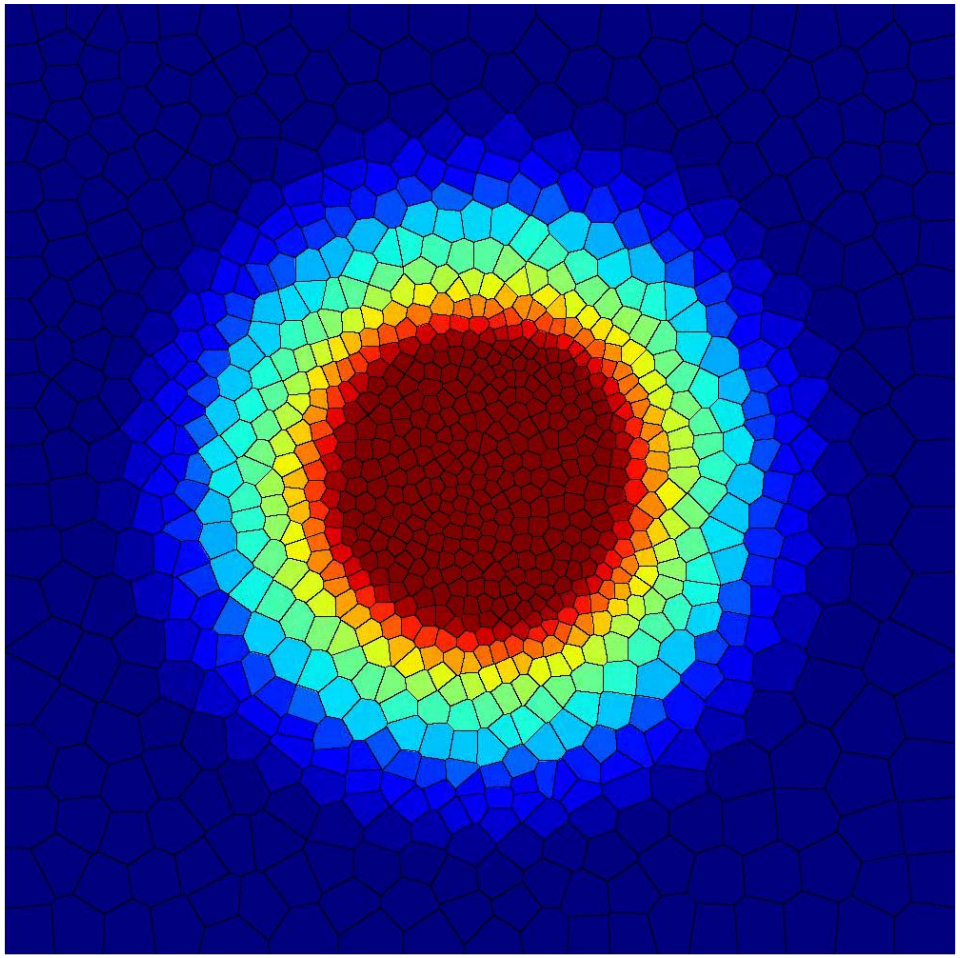


Valcke et al. 2008

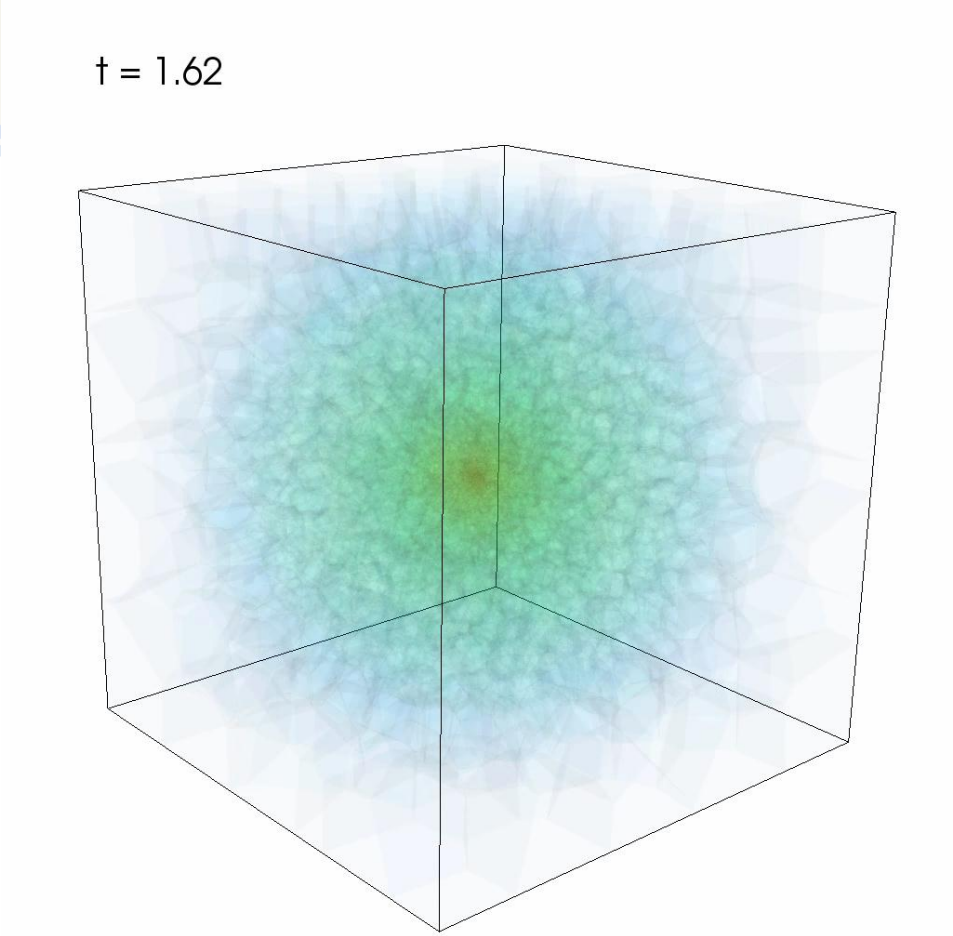
Solutions

- Use Adaptive Mesh Refinement (AMR)
- Use improved SPH
- Use a different method

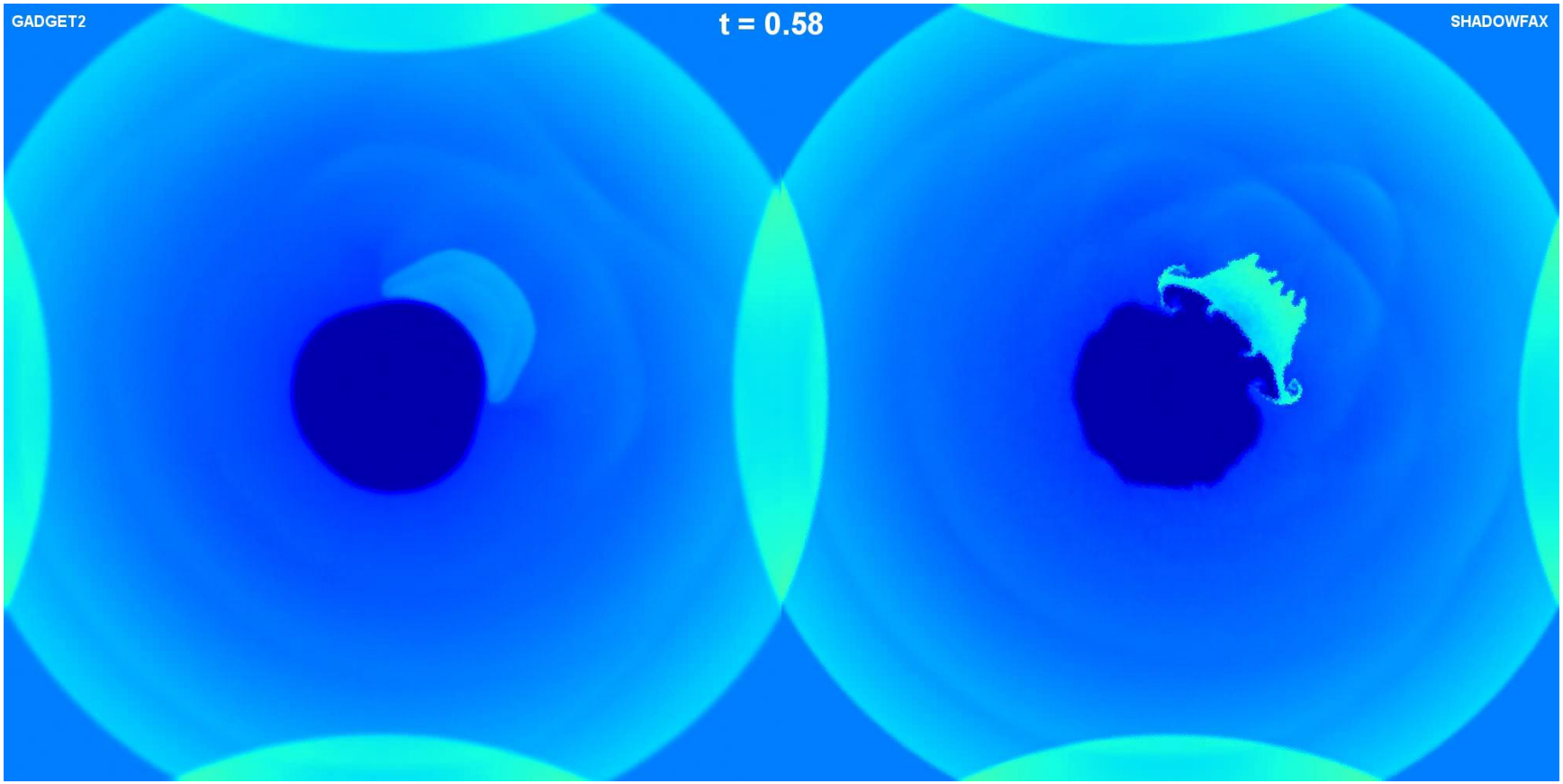
Moving mesh hydrodynamics



Moving mesh hydrodynamics

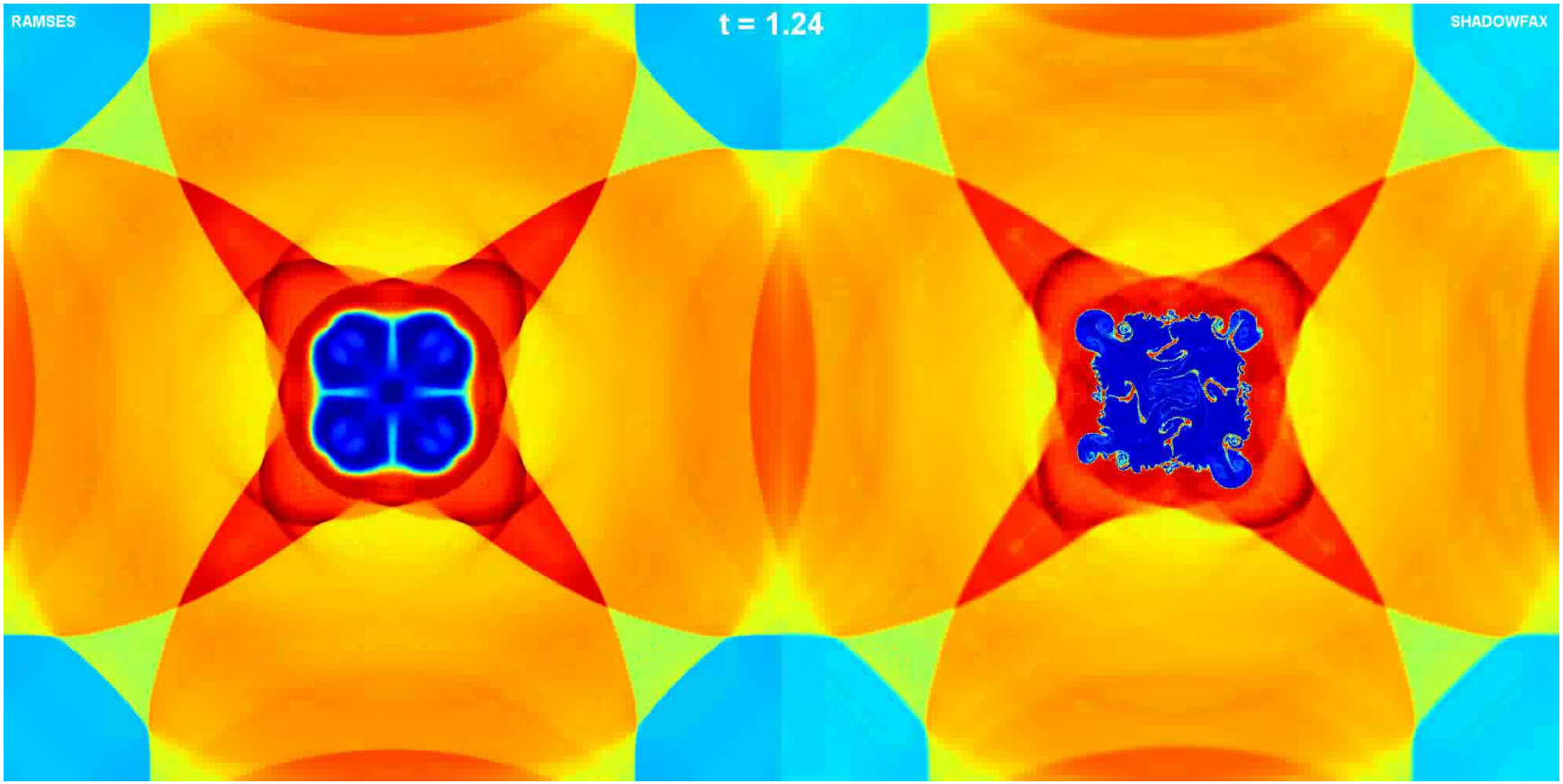


Shadowfax vs Gadget2



hadowfax

Shadowfax vs RAMSES



hadowfax

Moving mesh hydrodynamics

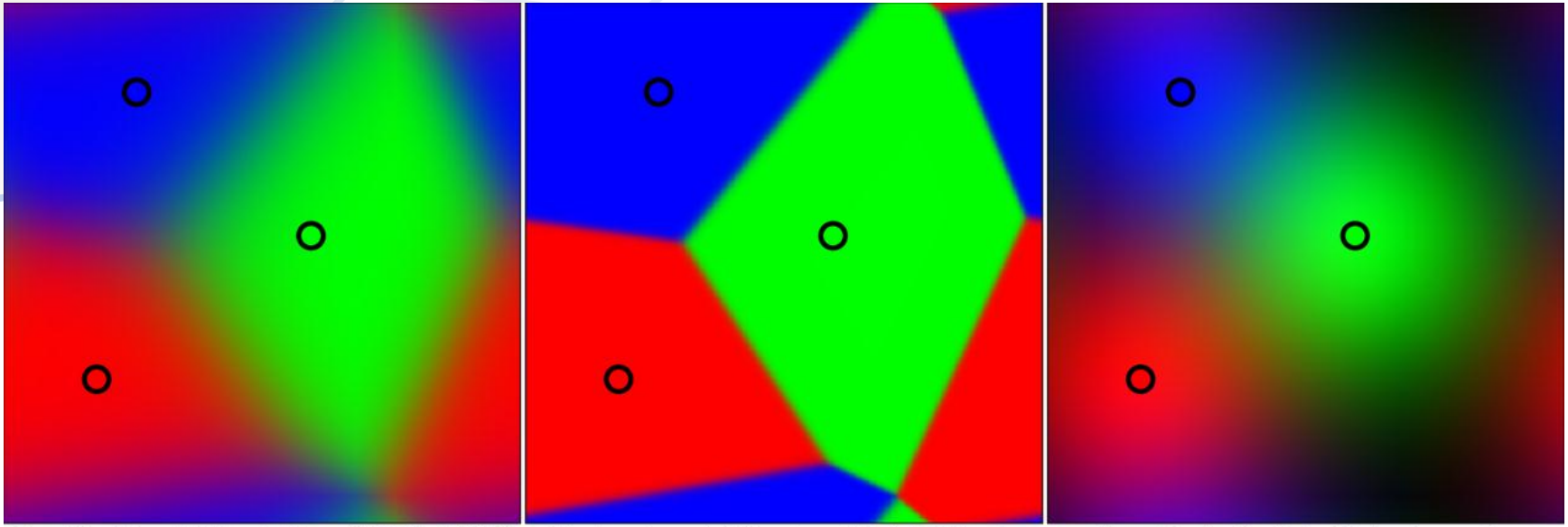
- *Springel* 2010: AREPO
- TESS, RICH, **Shadowfax**
- AREPO used for Illustris simulation (*Vogelsberger et al.* 2014)

- Uses moving Voronoi mesh combined with MUSCL-Hancock finite volume method

Computational aspects

- Building the mesh
  - Scaling is challenging
  - Large memory imprint
  - $\Rightarrow$ Possible solution: update the mesh (*BV et al. in preparation*)
- Hydrodynamical solver
  - Same as a fixed grid finite volume method
  - Choice of slope limiter, Riemann solver…

Mesh-free methods



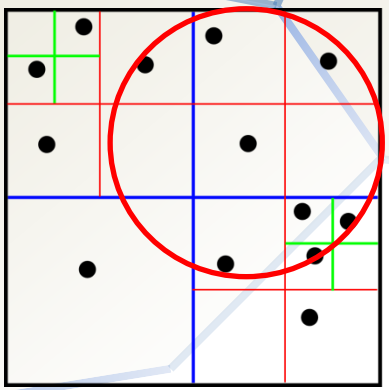
Hopkins 2014

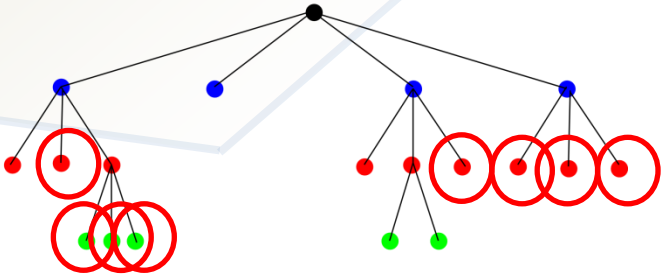
Mesh-free methods

- Particle-based: volumes through kernel-based volume partitioning
- Interface-based: hydrodynamics is flux exchange through inter-particle interfaces

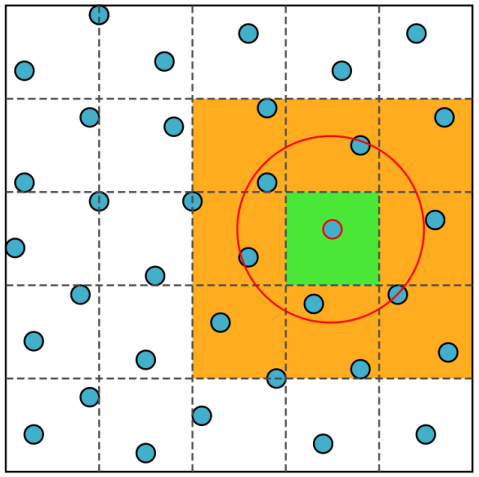
- Volume partitioning cheap because SPH-like
- Hydrodynamics good because finite volume

Volume partitioning: neighbours

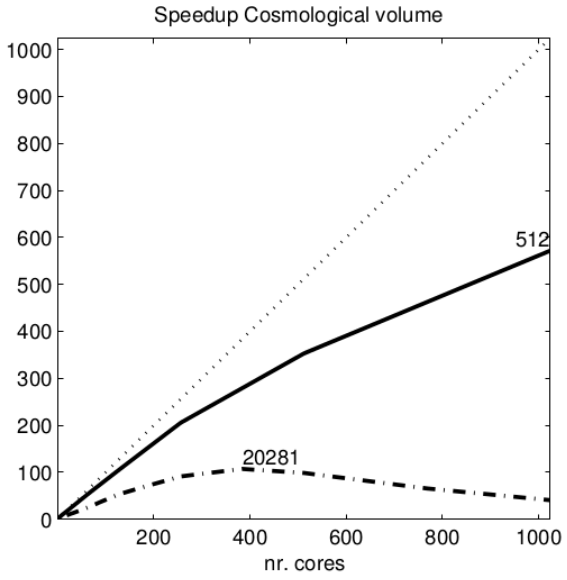


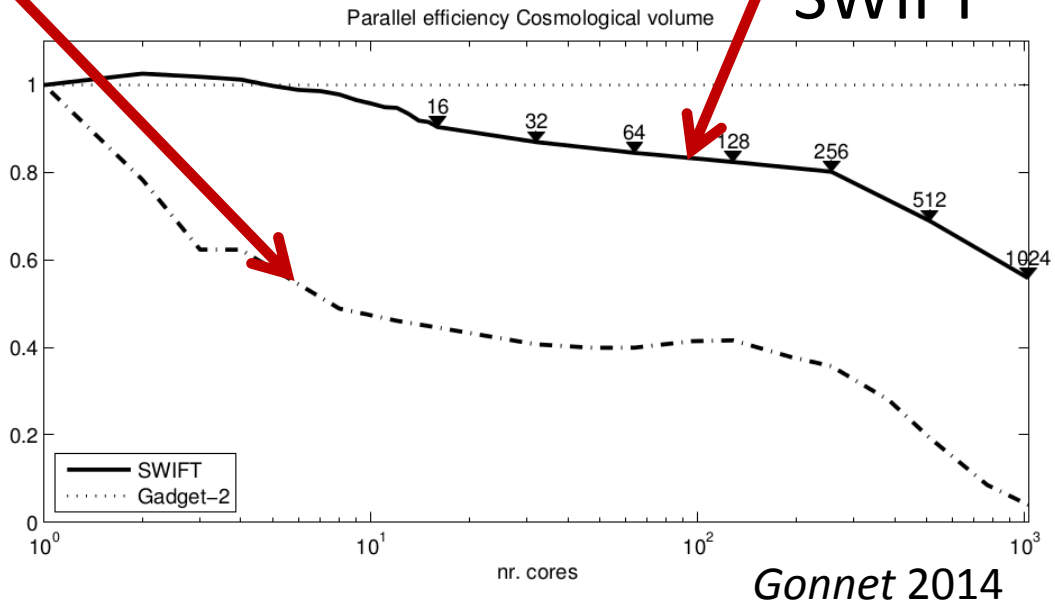


Tree-based



SWIFT

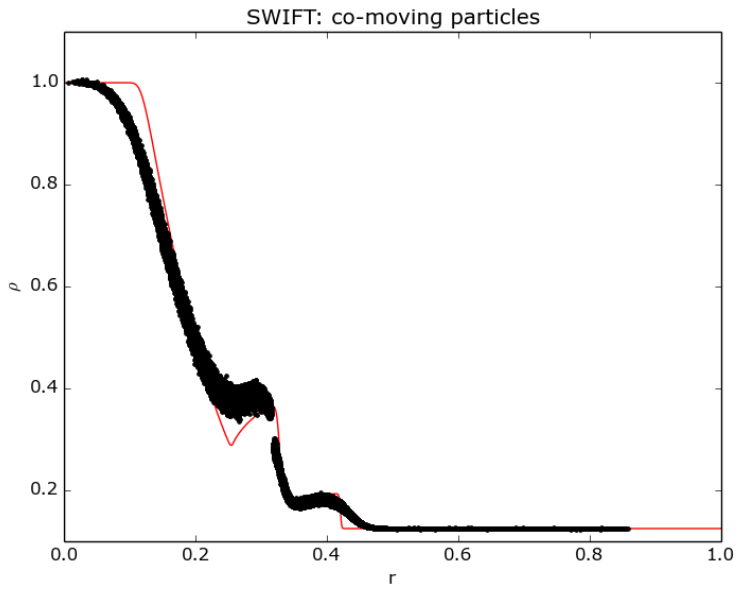




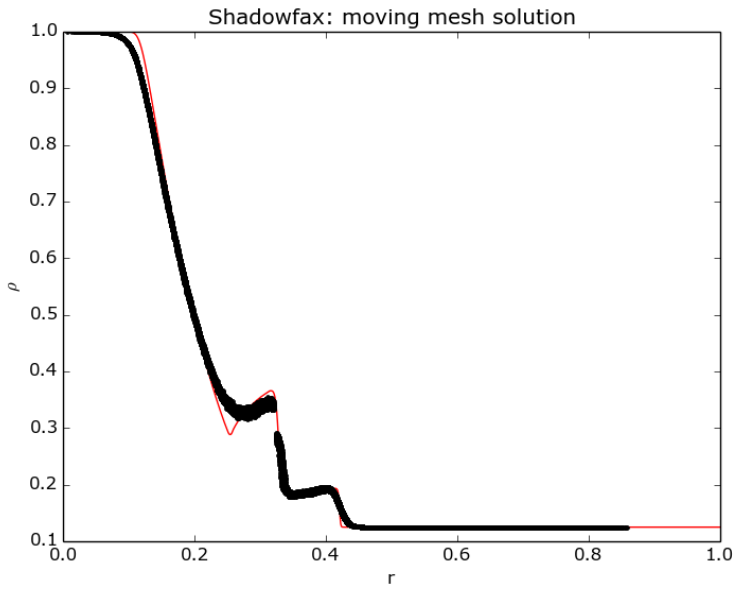
Gonnet 2014

Mesh-free methods

SWIFT



Shadowfax



Conclusion

- Standard SPH should not be used
- Moving mesh method has superior resolution compared to other techniques
  BUT is computationally expensive
- Mesh-free methods promising compromise between resolution and effectiveness
  BUT young and immature