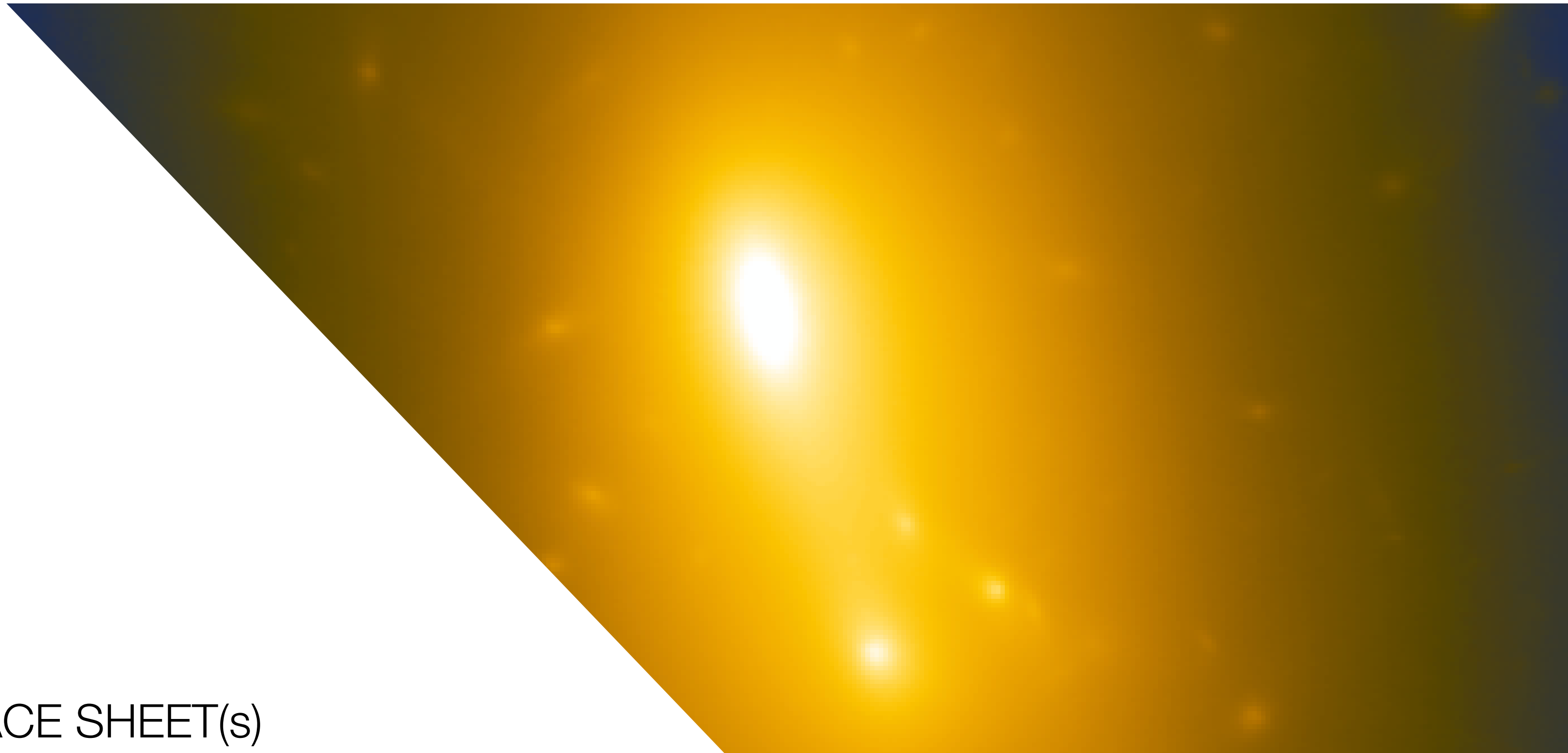

# Collisionless Fluids: USING PHASE SPACE SHEET(s)

TOM ABEL
KIPAC/STANFORD

# Summary: What's it good for?

- Analyzing N-body sims, including web classification, velocities, dispersions, f(v)dv, …
  (Abel, Hahn, Kaehler 2012)
- Dark Matter visualization (also plasmas)
  (Kaehler, Hahn, Abel 2012)
- Better Numerical Methods
  (Hahn, Abel & Kaehler 2013, Hahn, Angulo & Abel 2014 in prep)
- WDM mass functions below the cutoff scale
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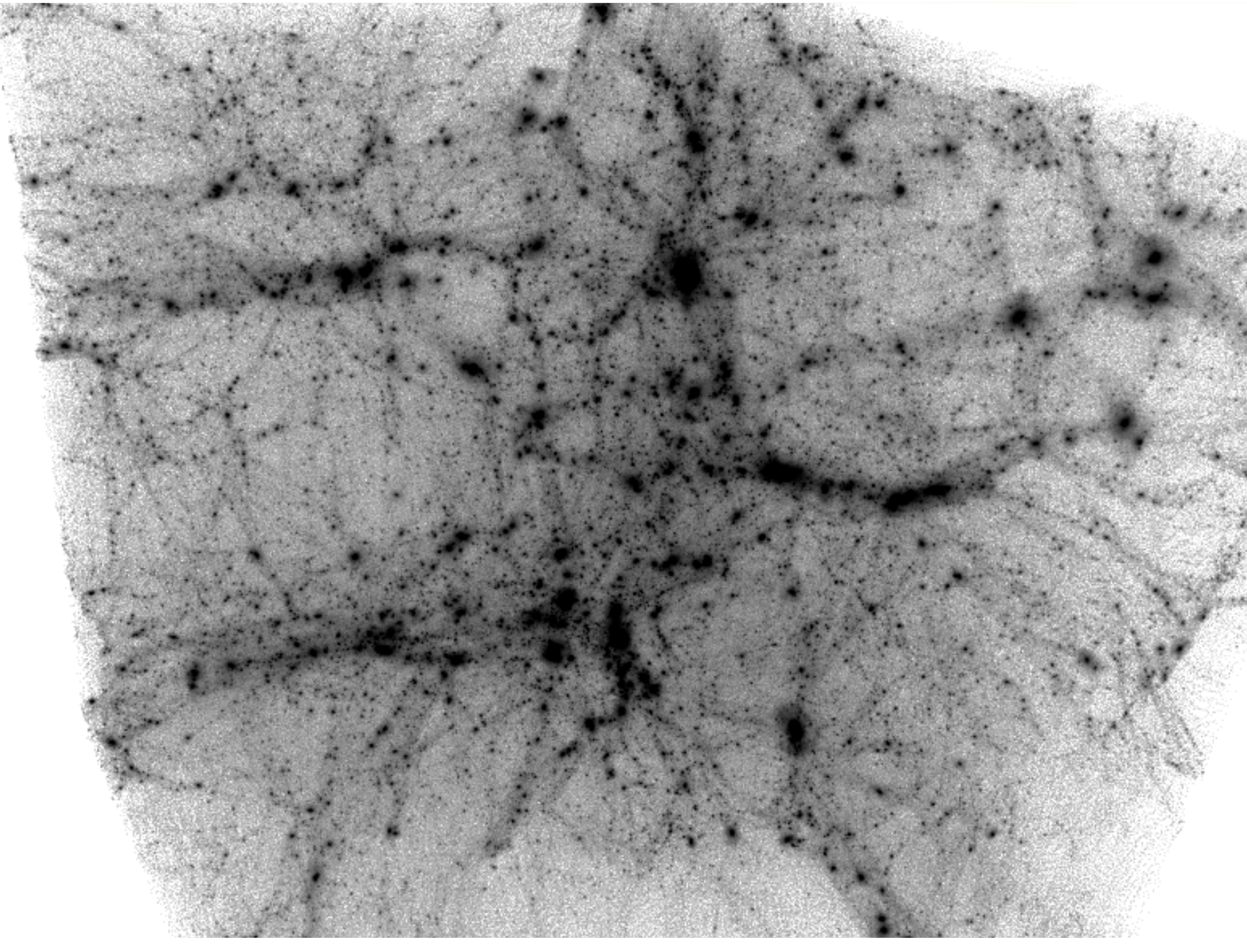
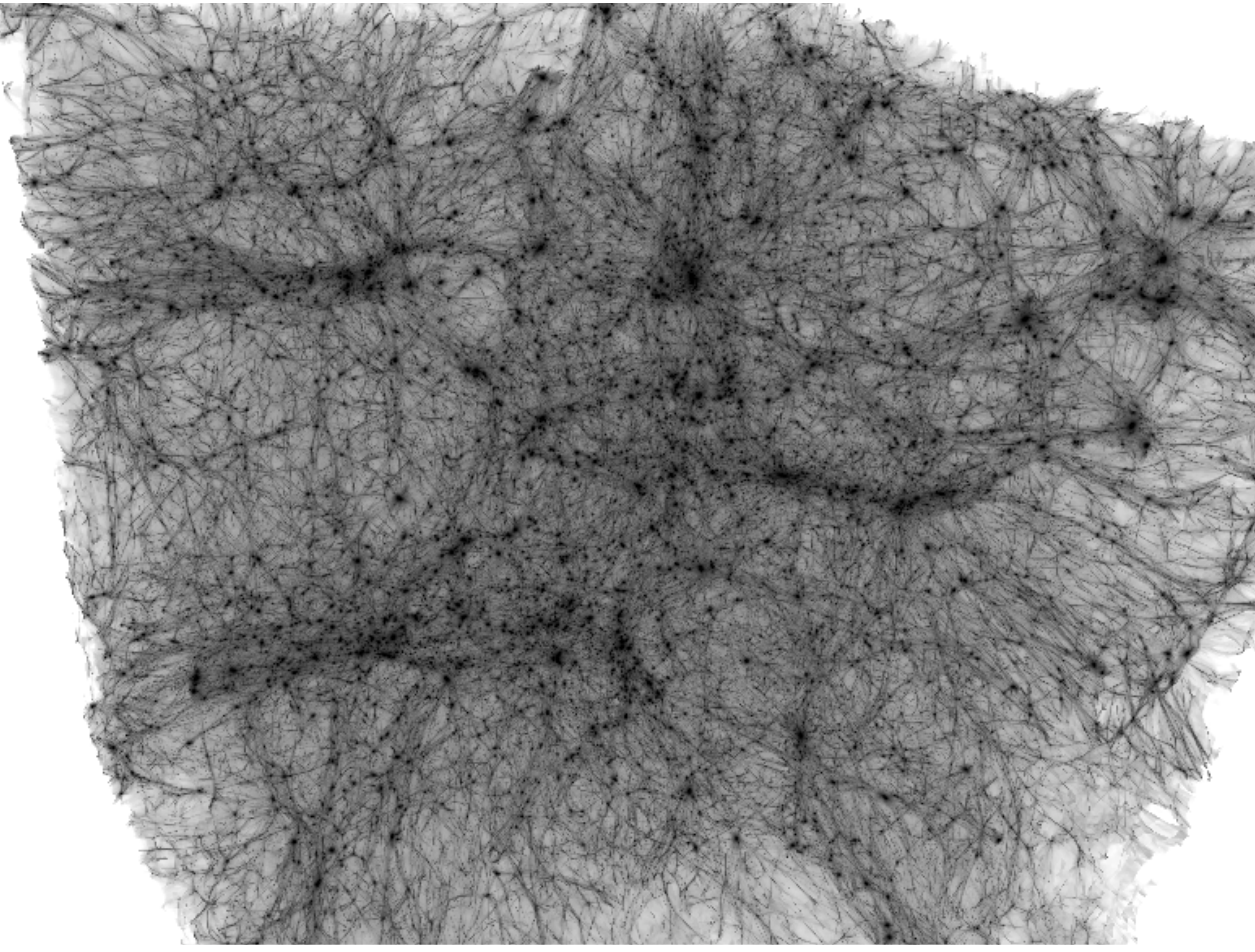
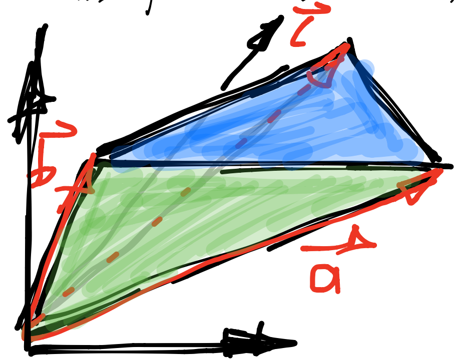
  (Powell & Abel in prep.)
- Exact deposition possible!
- your application here ?





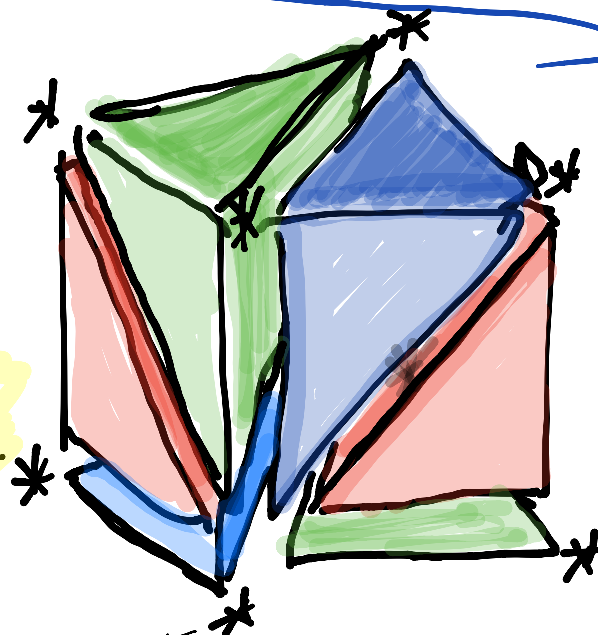
# 3 dimensional manifold in 6D Phase Space

- Natural tessellation takes unit cube & splits it into six equal size tetrahedra.
- mass per tetrahedron = 1/6 of DM particle mass.

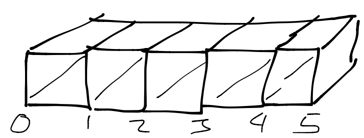



$$V = \frac{|\vec{a}\cdot(\vec{b}\times\vec{c})|}{6}$$

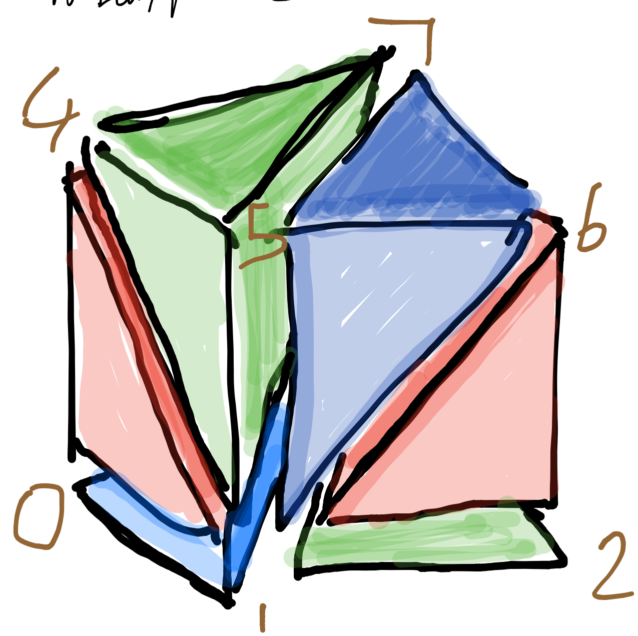
$$\Rightarrow \rho = \frac{m_p}{6V} = \frac{m_p}{|\vec{a}\cdot(\vec{b}\times\vec{c})|}$$




- Number the edges of the cube
- think of lattice
- Looping over

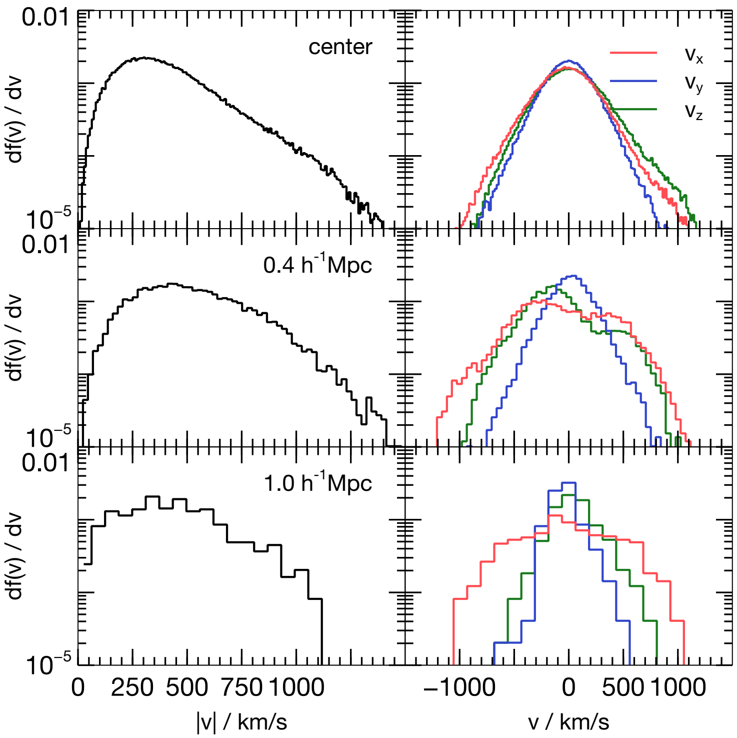


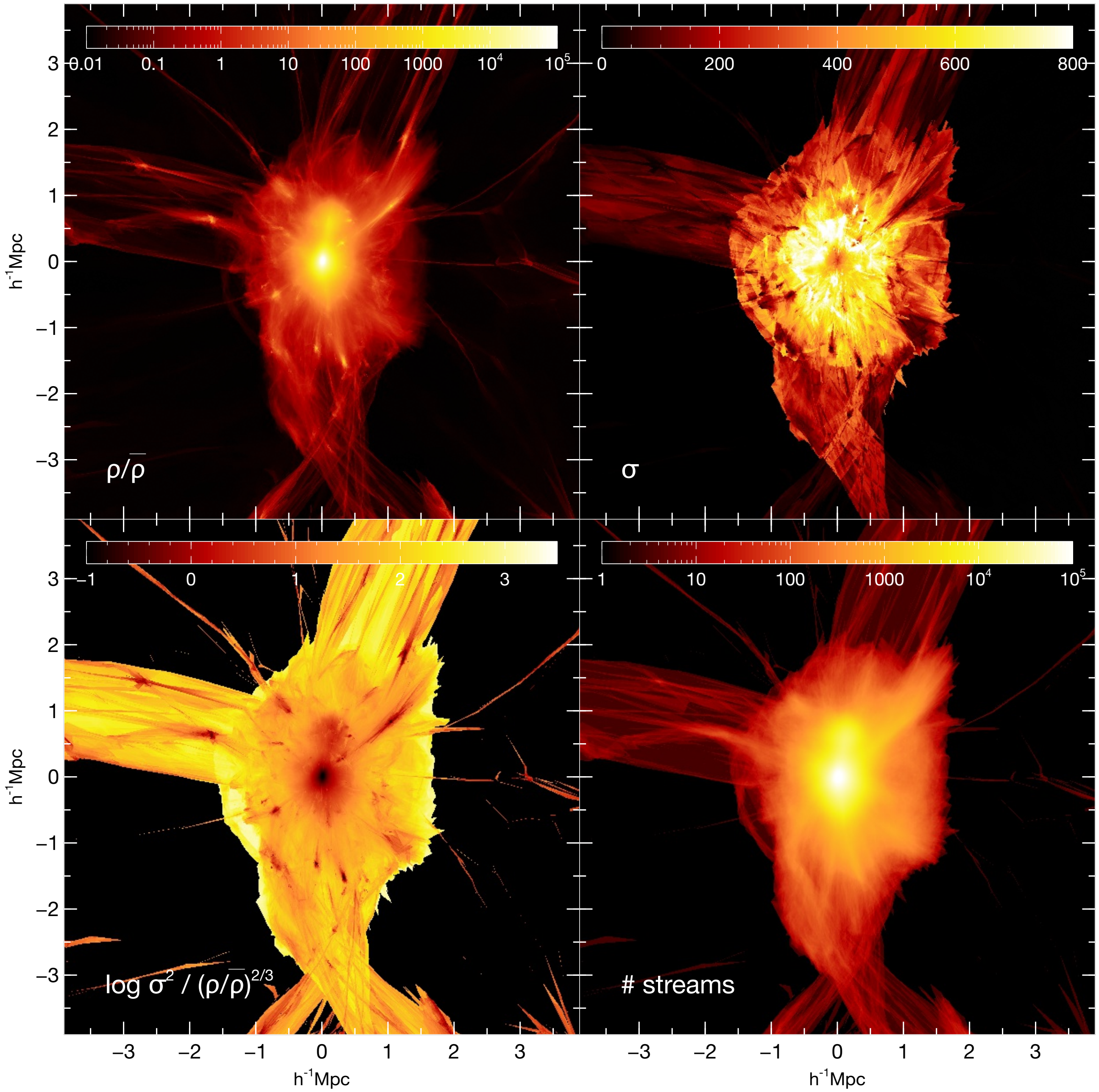

the initial cartesian (LAGRANGIAN) lattice generates the 6N tetrahedra.

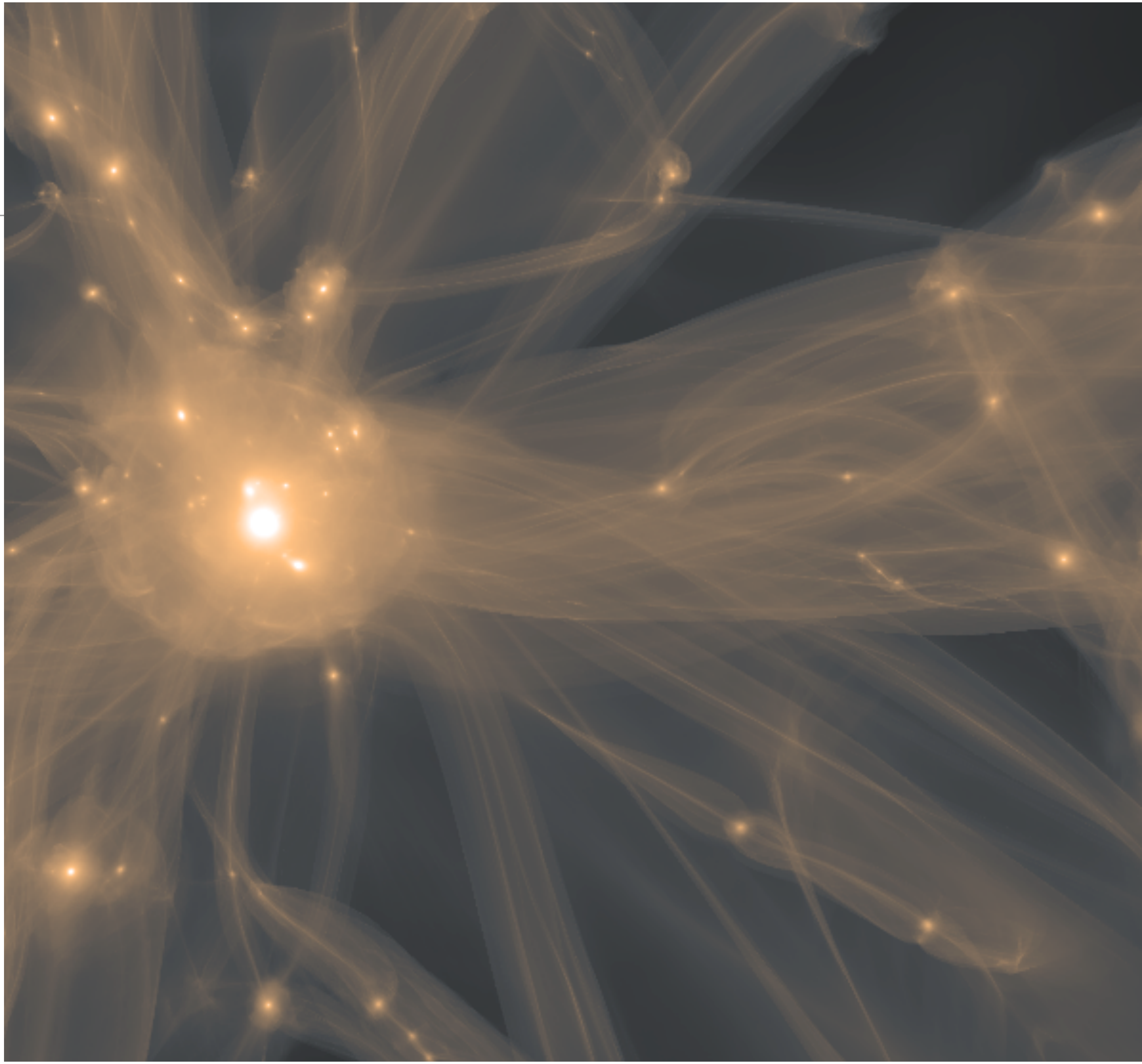


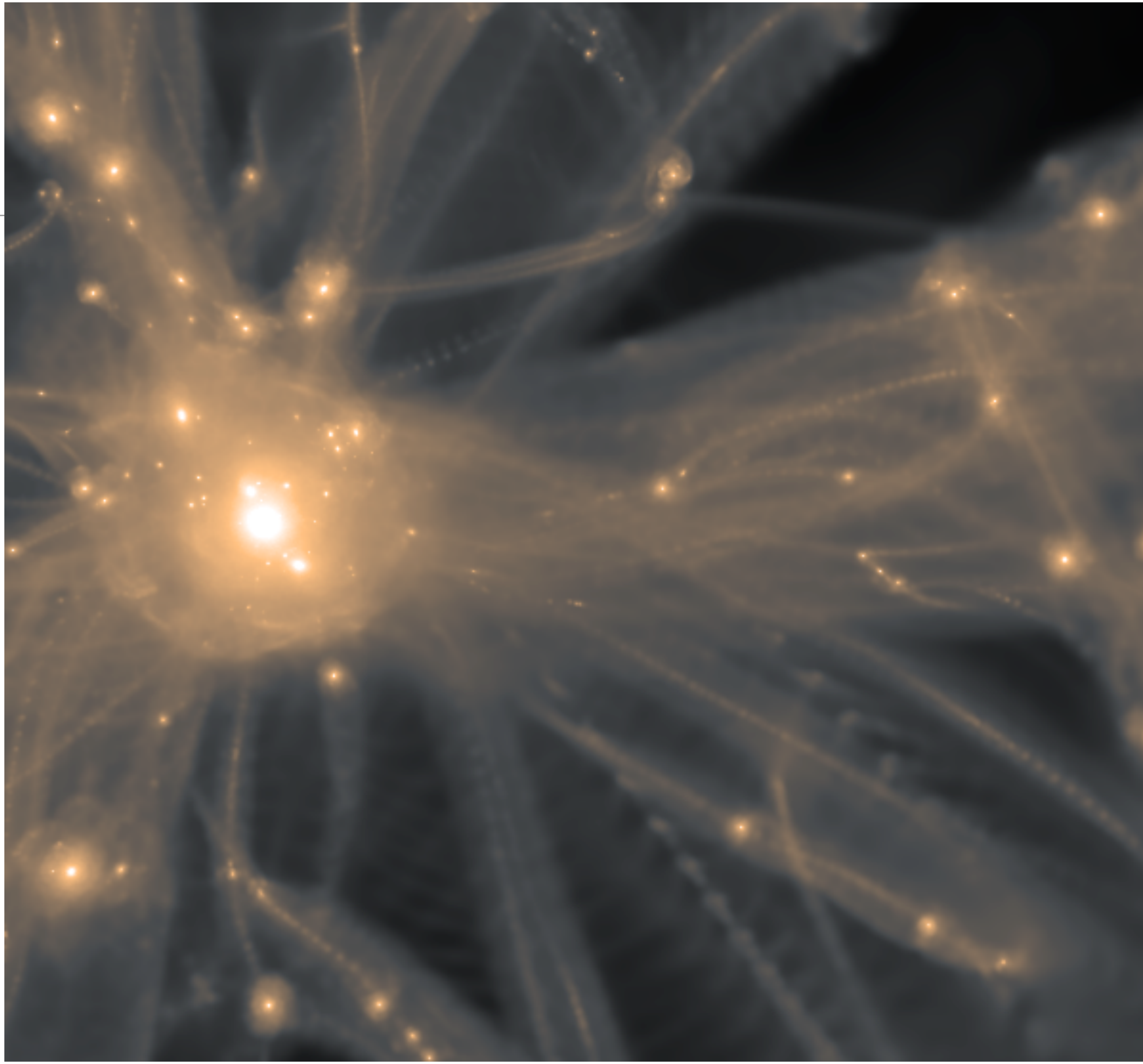
# A first glimpse: analyzing phase space

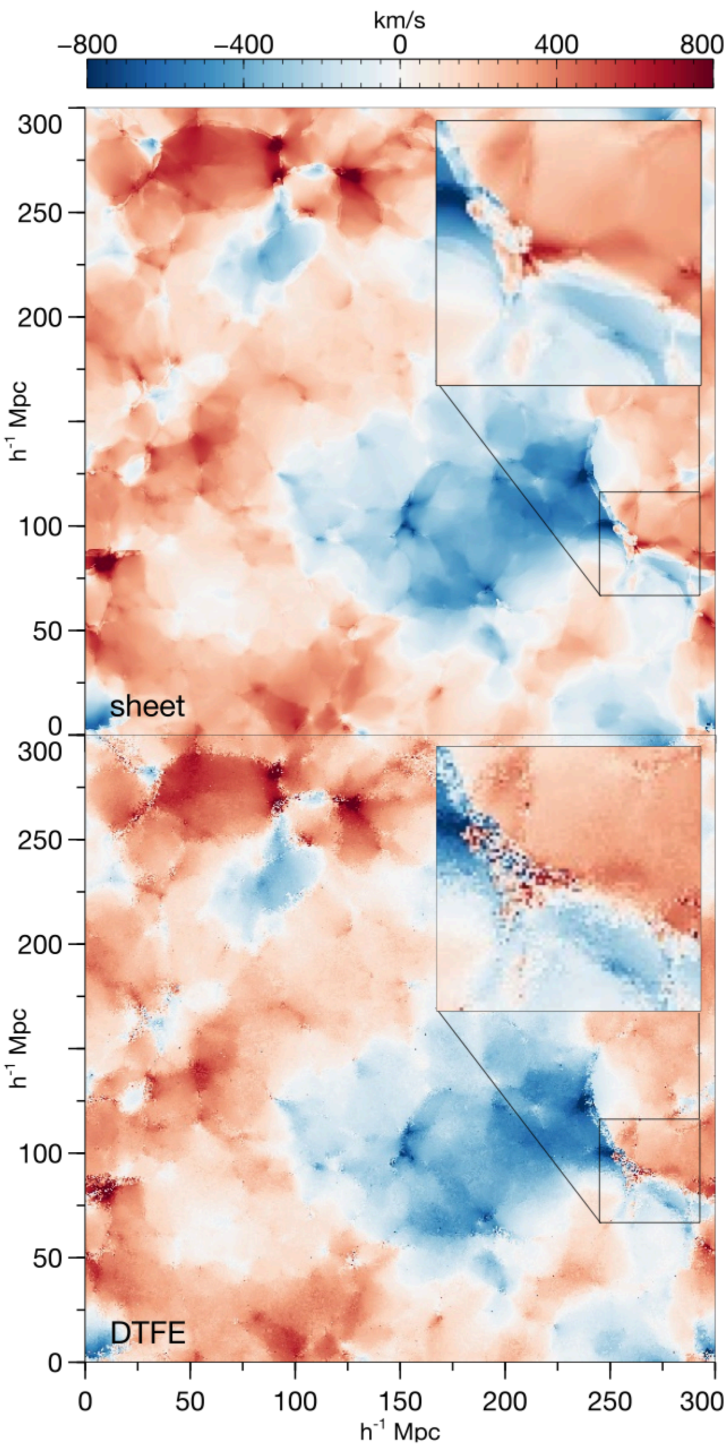
can probe
fine-grained
phase space
structure.



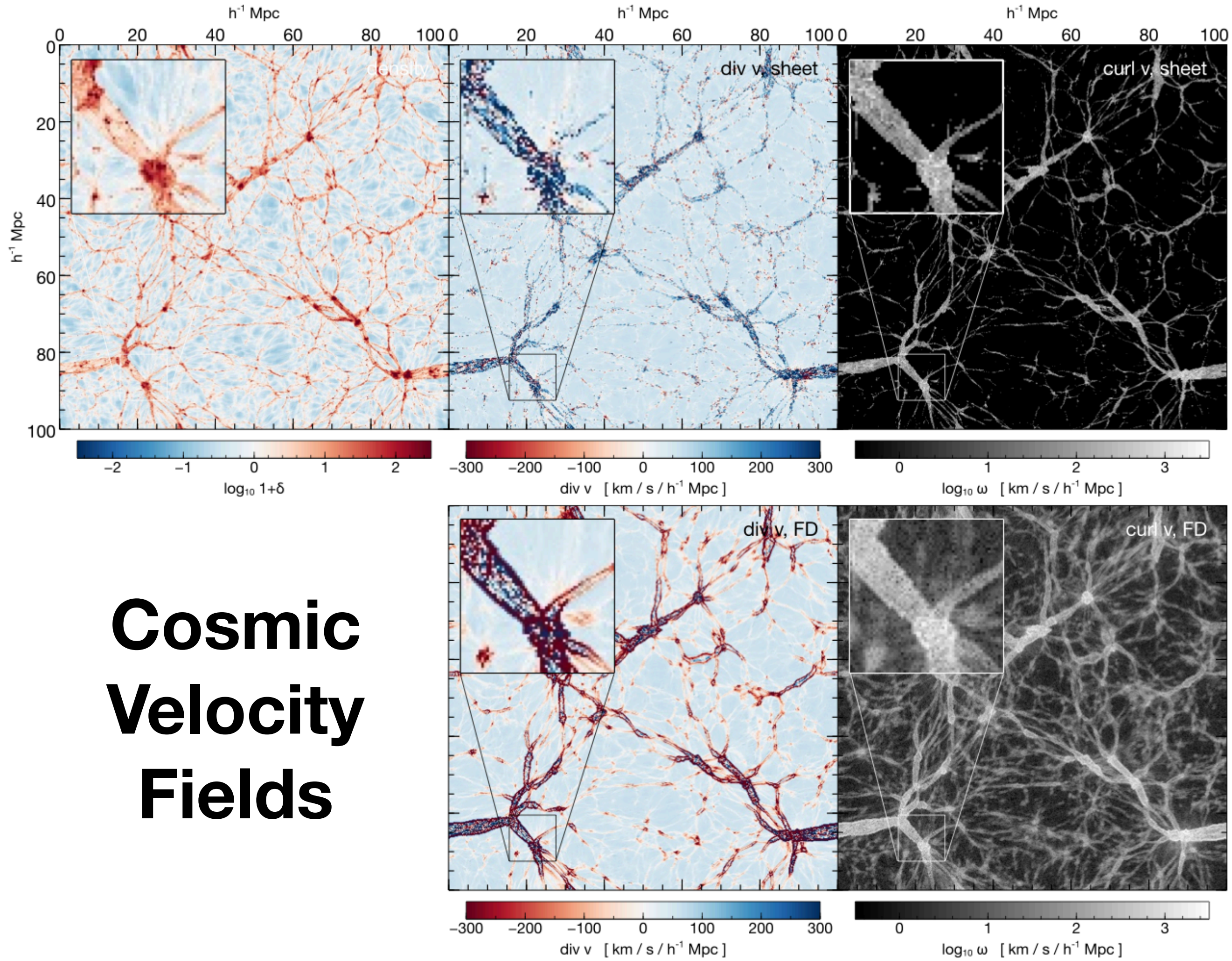



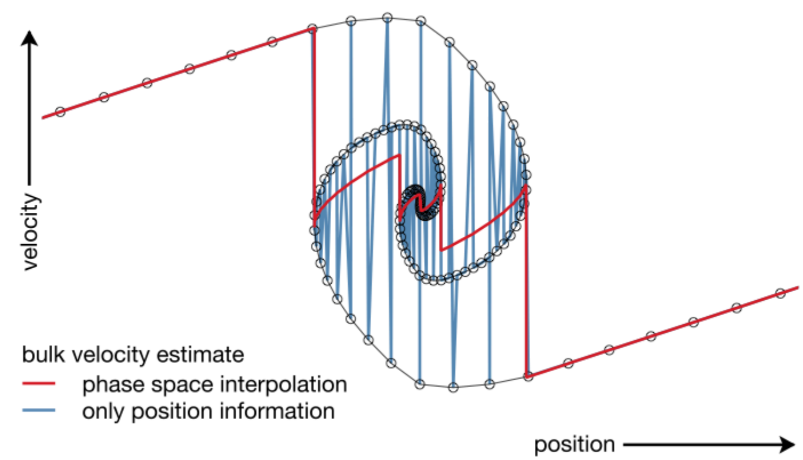






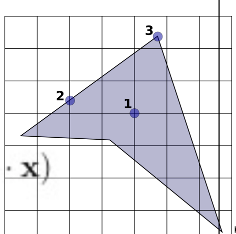

# Cosmic Velocity Fields



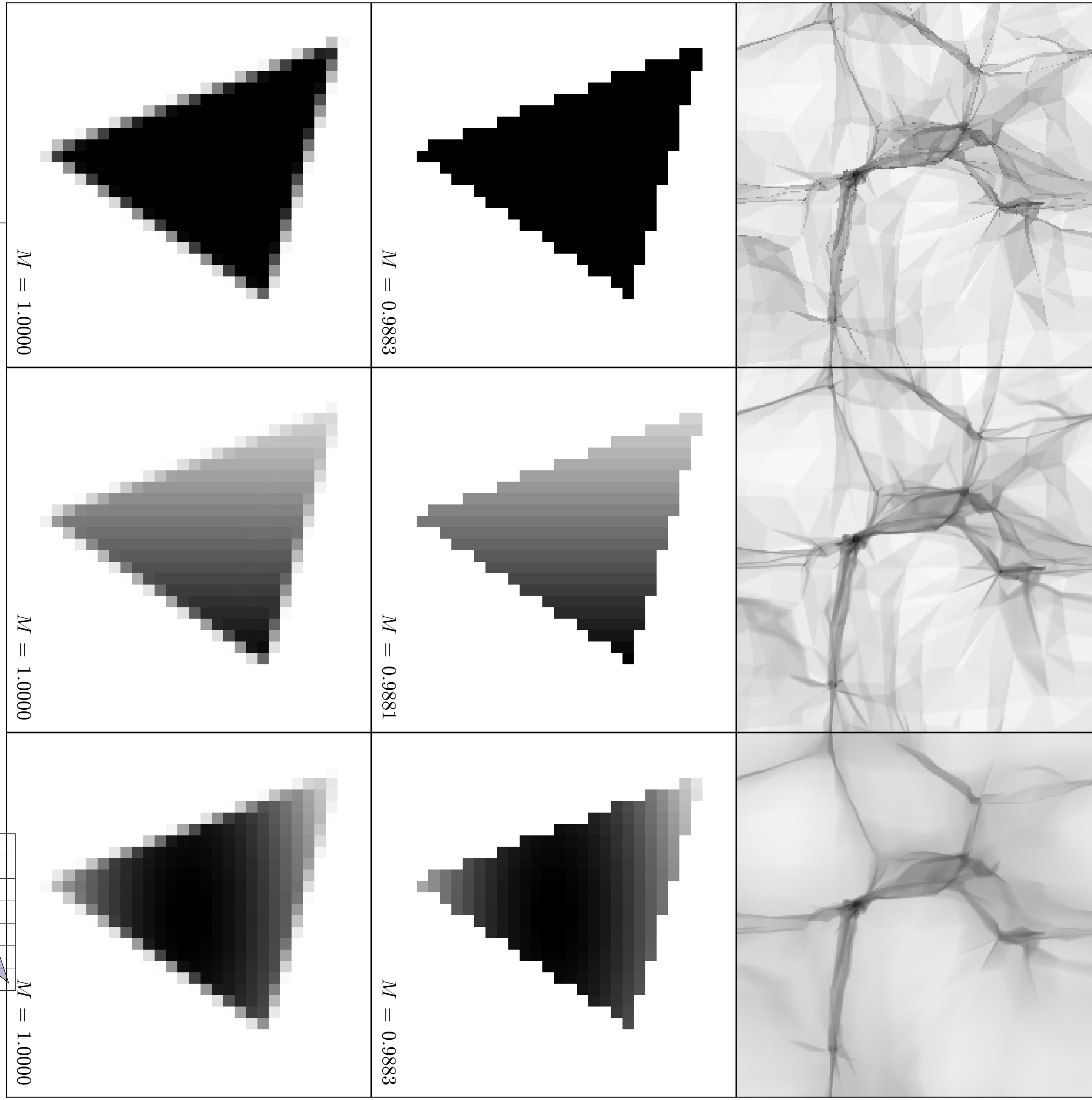
# Exact Deposit

- any polyhedra intersections without constructing the overlap
- linear and quadratic function defined over polyhedra
- fundamental building block for many novel algorithms
- 30 times faster than a recursive algorithm
- Computational Geometry - Patent?

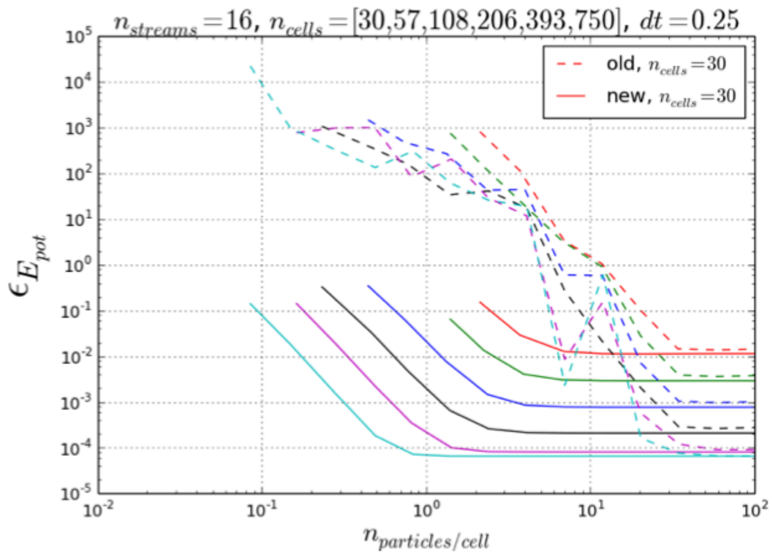



$$A = \frac{1}{2}\sum_{e,p}(\hat{\mathbf{n}}_e \cdot \mathbf{x})(\hat{\mathbf{n}}_p \cdot \mathbf{x})$$

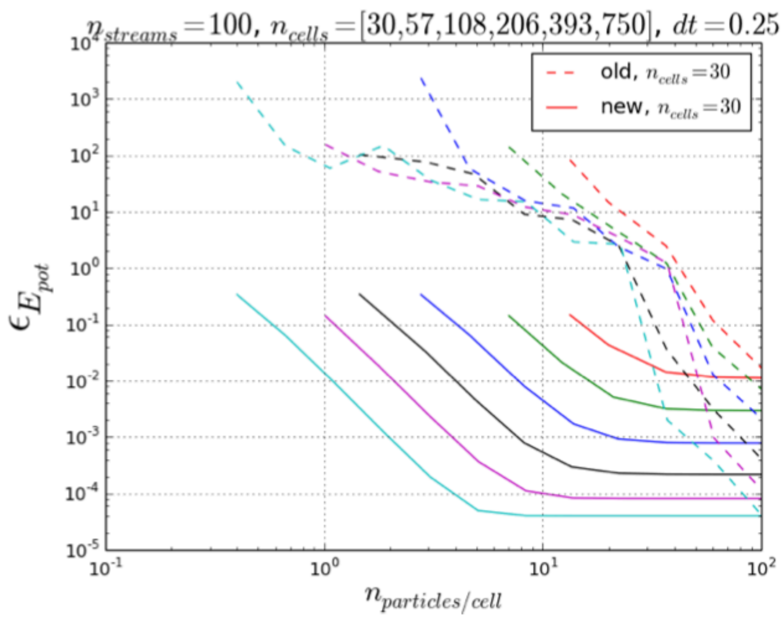
$$V = -\frac{1}{6}\sum_{f,e,p}(\hat{\mathbf{n}}_f \cdot \mathbf{x})(\hat{\mathbf{n}}_e \cdot \mathbf{x})(\hat{\mathbf{n}}_p \cdot \mathbf{x})$$



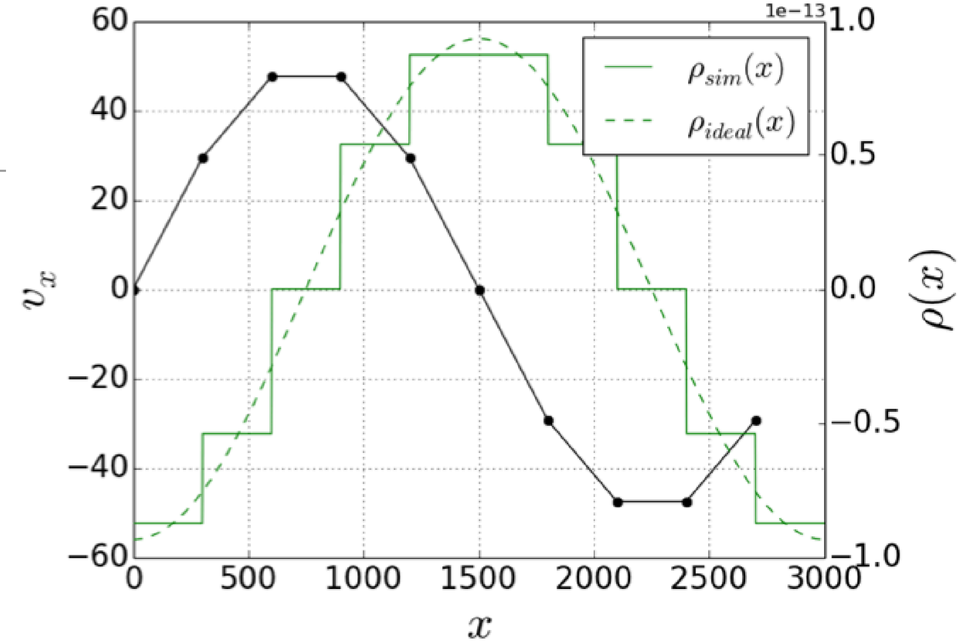
# Collisionless Plasma



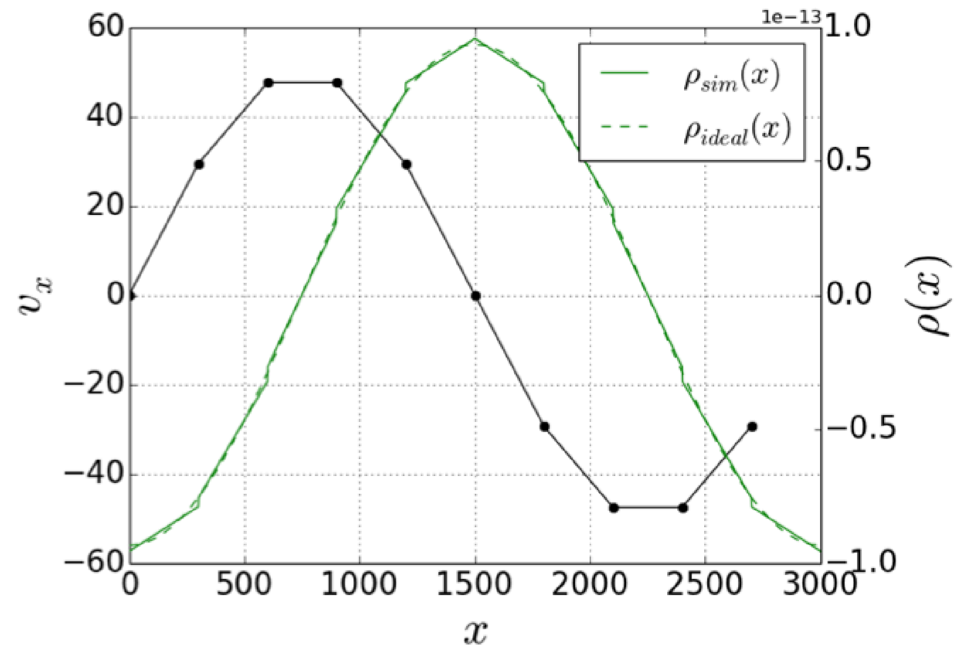

(b) Piecewise linear

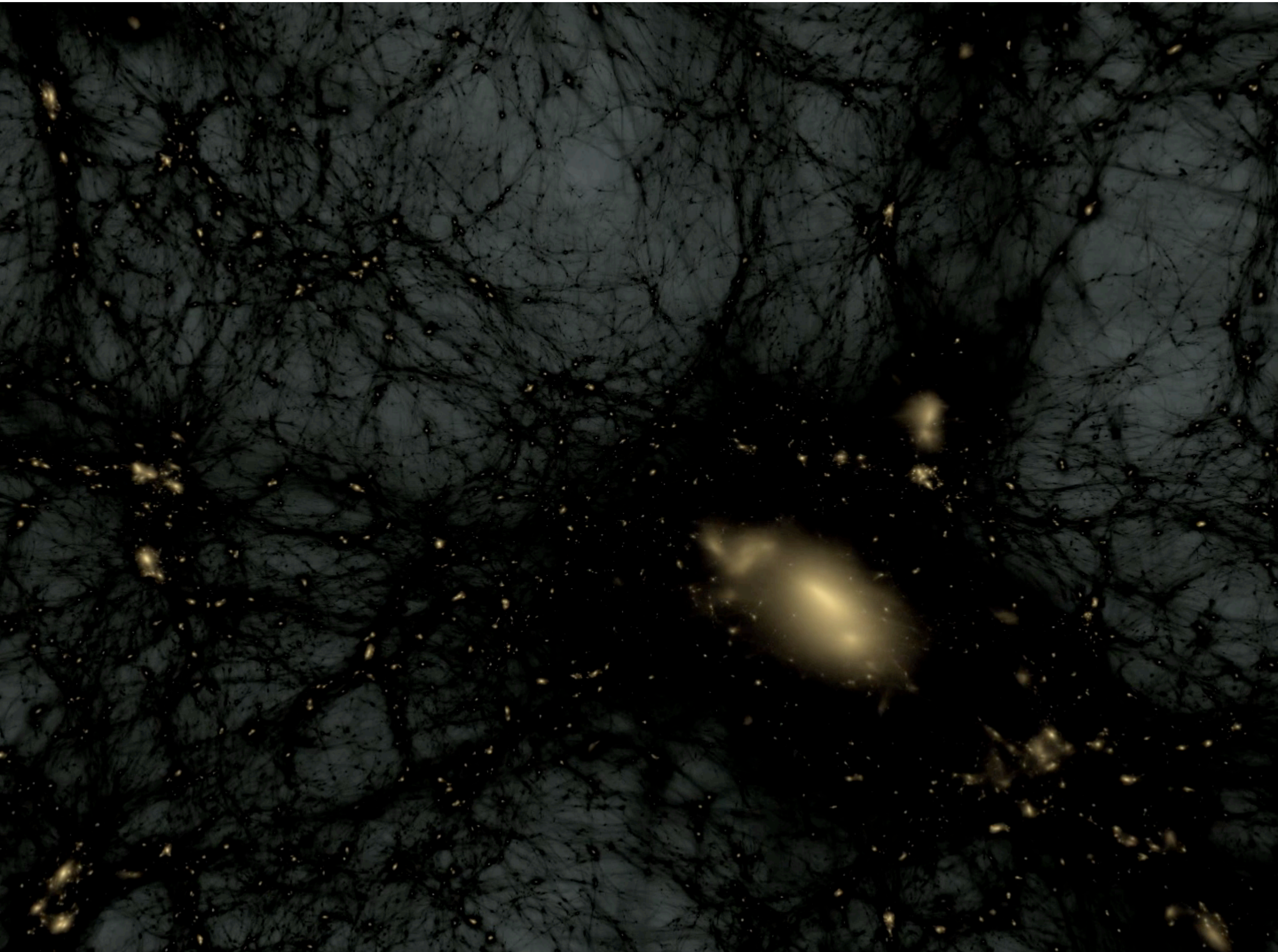



(a) PIC




(b) SIC: piecewise constant segments





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