A 1-1, volume and local structure preserving remapping of periodic cubic boxes

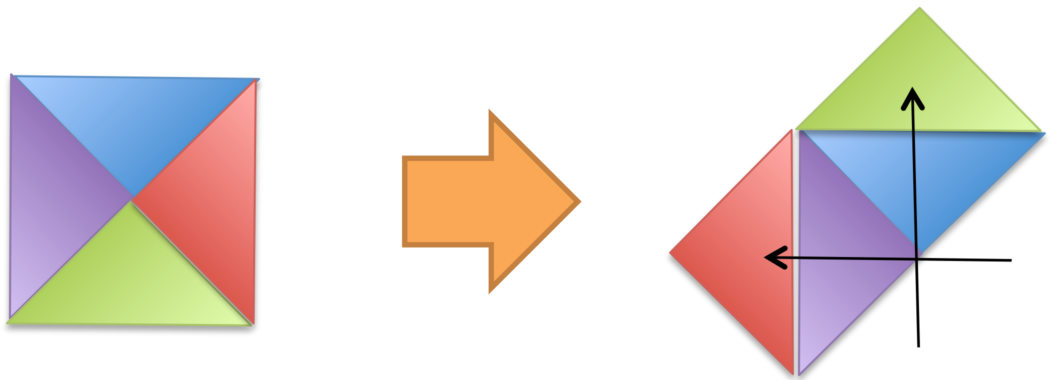
Jordan Carlson & Martin White
UC Berkeley, LBNL
(paper, in prep)

Remapping a cubic volume

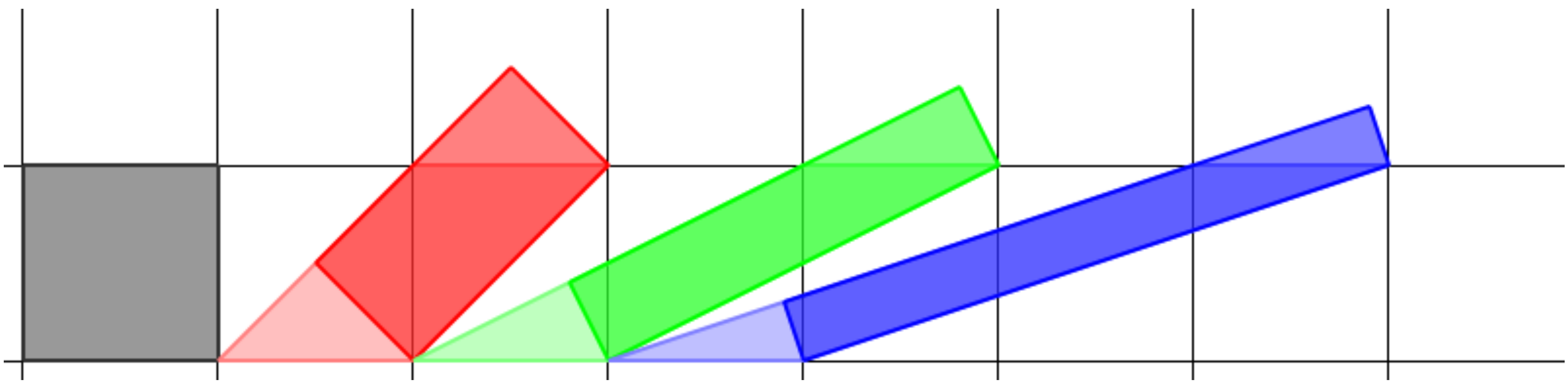
- Running simulations in non-cubical volumes has numerical issues.
- Sometimes the desired geometry is not cubical.
- By viewing the periodic cube as a hyper-torus one can devise "wrappings" of light rays which generate light-cones or cube remappings which allow non-cubical geometries.
  - But this can become complex.
- We have a new way of thinking about generating non-cubical geometries from cubical simulations which is
  - Fast (so can do on-the-fly calculations, e.g. lightcones)
    - Computer graphics, "collision detection".
  - Volume preserving (one longer and two shorter sides).
  - One-to-One: every particle appears once and only once.
  - Structure preserving
    - Local neighboring structures are mapped to neighboring places.

Two views (2D): shifting and shearing

$$1 \times 1$$

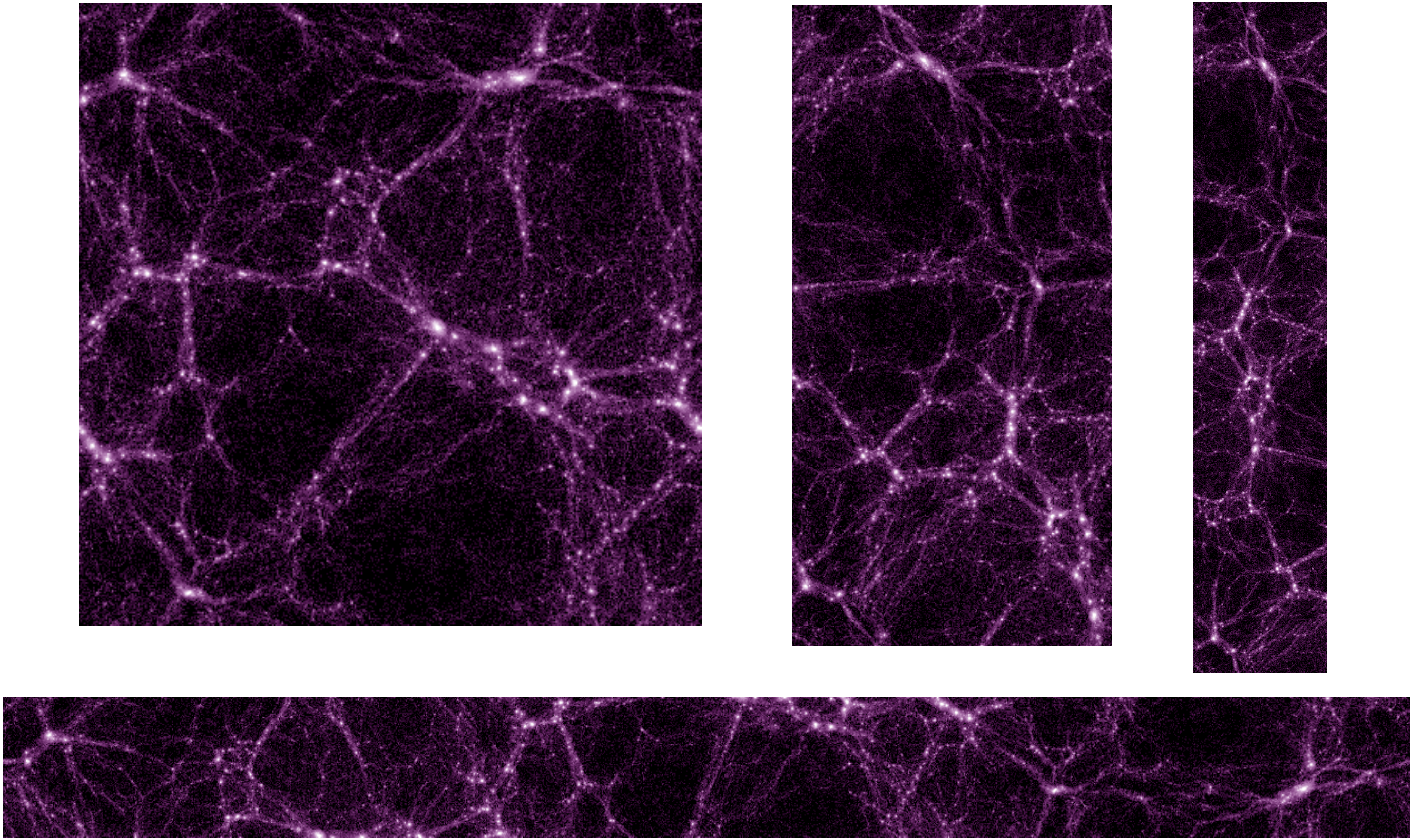


$$\sqrt{2} \times \frac{1}{\sqrt{2}}$$



Example: a slice through a simulation

(Can mask "boundaries" if desired)



Possible final shapes

- **The method generalizes easily to 3D and gives a fast way of evaluating the remapping.**
- **Final possible configurations are specified by integers *m* and *n* s.t.**

$$L_x = \sqrt{1+m^2+n^2}\ ,\ L_y = \frac{\sqrt{1+n^2}}{\sqrt{1+m^2+n^2}}\ ,\ L_z = \frac{1}{\sqrt{1+n^2}}$$

- **For example, for a cube 500h^{-1}Mpc on a side (e.g. Millennium)**

(*m*,*n*)	L_x	L_y	L_z
(0,2)	1120	500	220
(1,1)	870	410	350
(3,2)	1870	300	220

For example: DC5-like geometry

- Consider a "survey" 100 sq. deg. to z=1.
  - z=1 is χ=2400 h^{-1}Mpc, so 10 deg is ~400h^{-1}Mpc (comoving) on a side.
  - Total volume is 2400x400x400(h^{-1}Mpc)^3~4x10^8 (h^{-1}Mpc)^3~(700 h^{-1}Mpc)^3
  - If we run a 1h^{-1}Gpc box we can embed this easily as (e.g.)

(m,n)	L_x	L_y	L_z
(1,2)	2450	910	450
(2,1)	2450	580	710
(2,2)	3000	750	450
(3,1)	3320	430	710
(3,2)	3740	600	450

Can do 2 regions side by side (volume ratio is 2.6)

The End