

From Origami Tessellations (Tilings) to the Cosmic Web

Mark Neyrinck

Institute for Astronomy

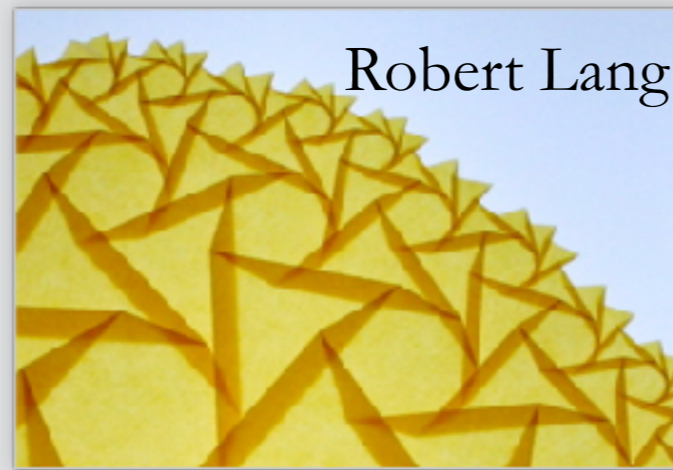
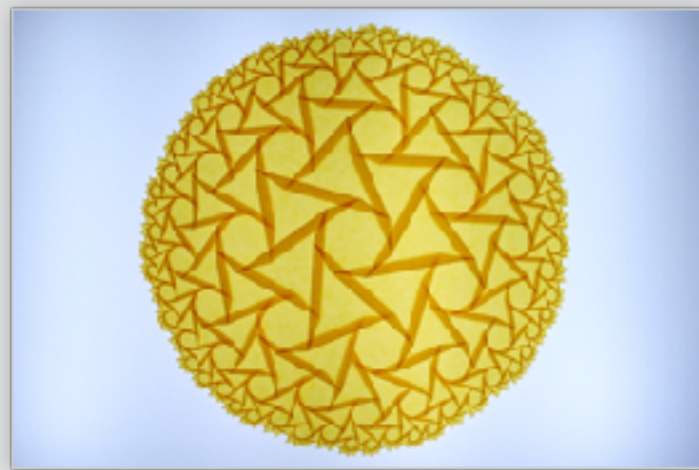
University of Hawai‘i at Mānoa

Blue Marble Space

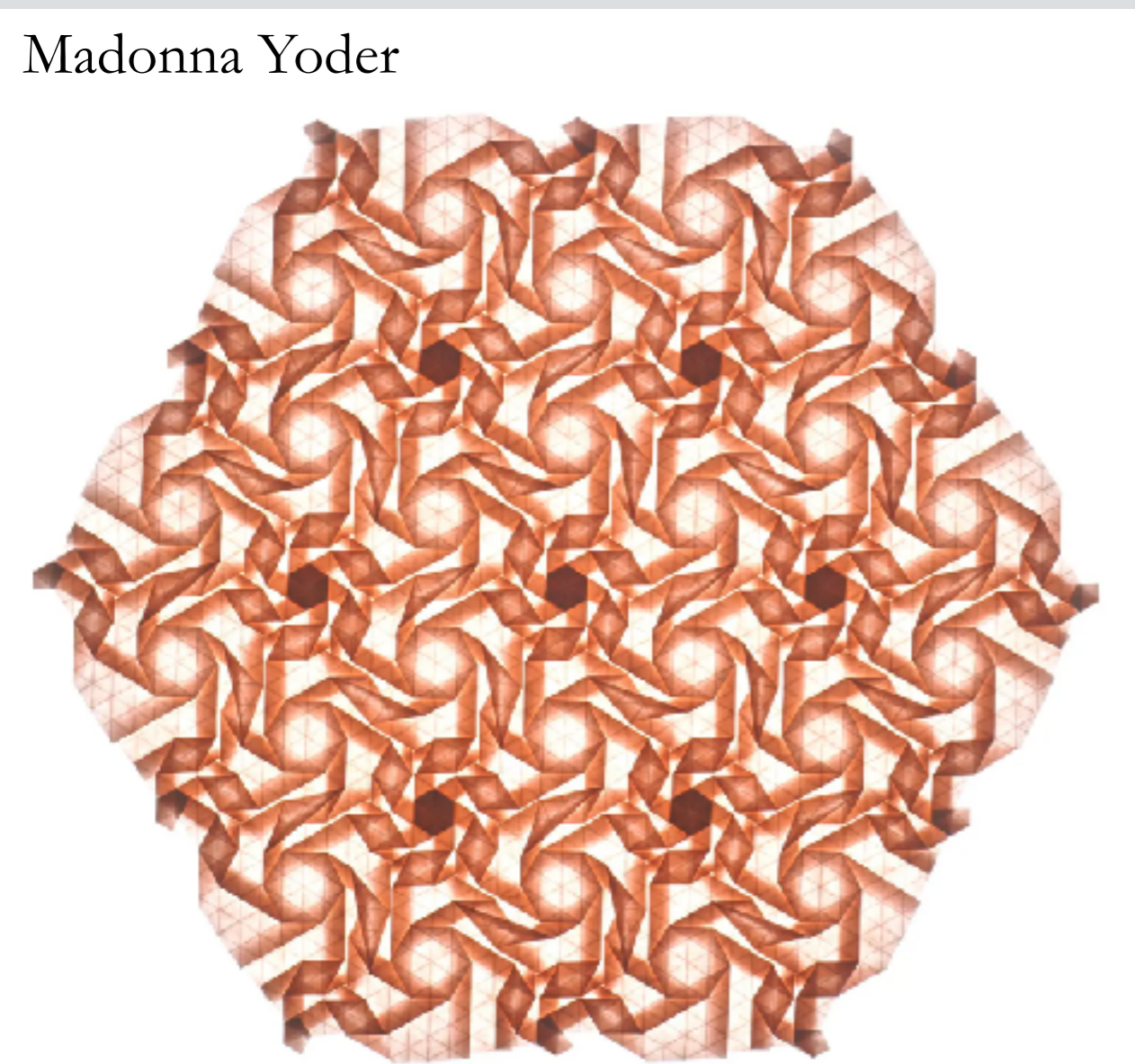
CfC6, Ann Arbor

May 14, 2026

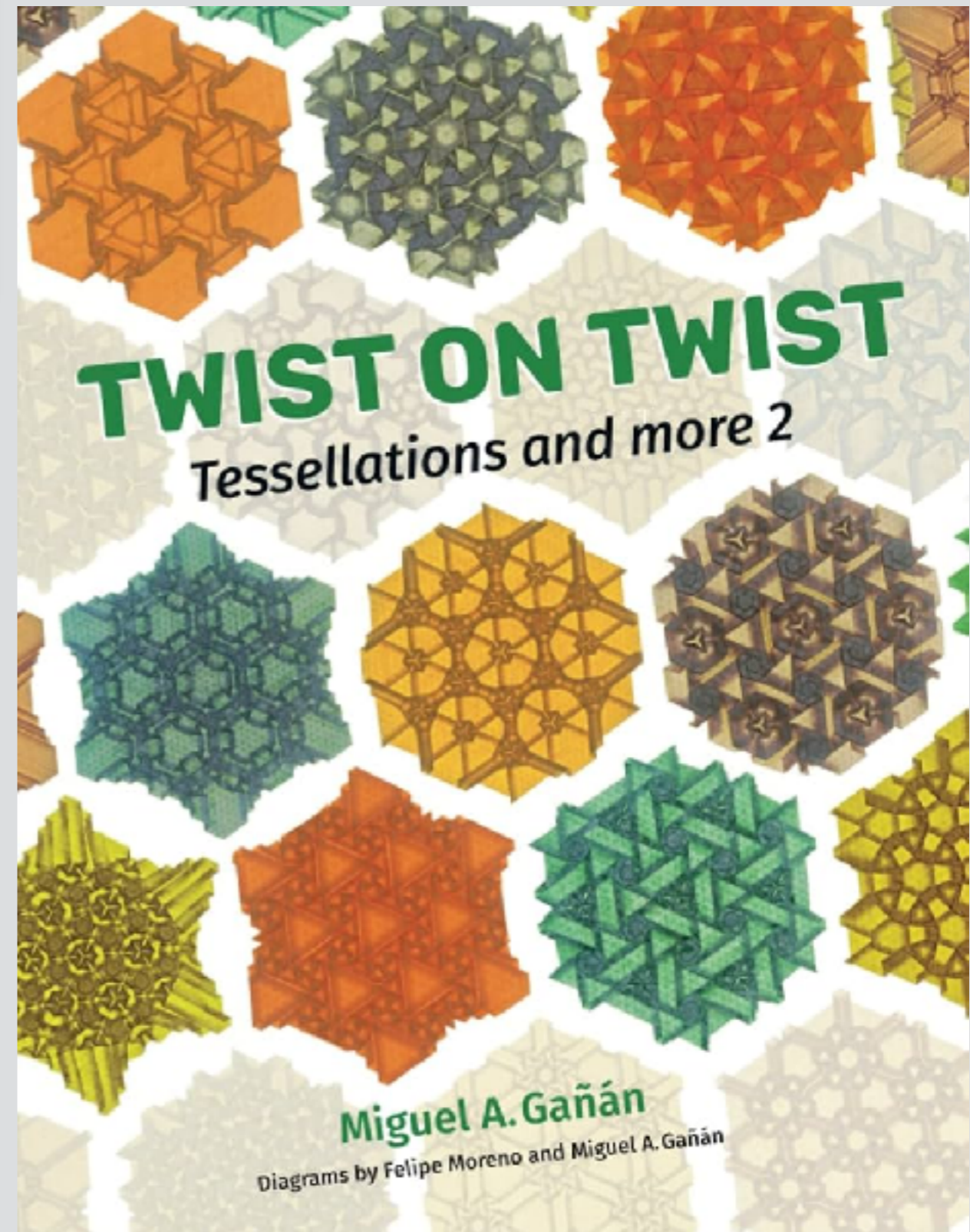
Origami tessellations!



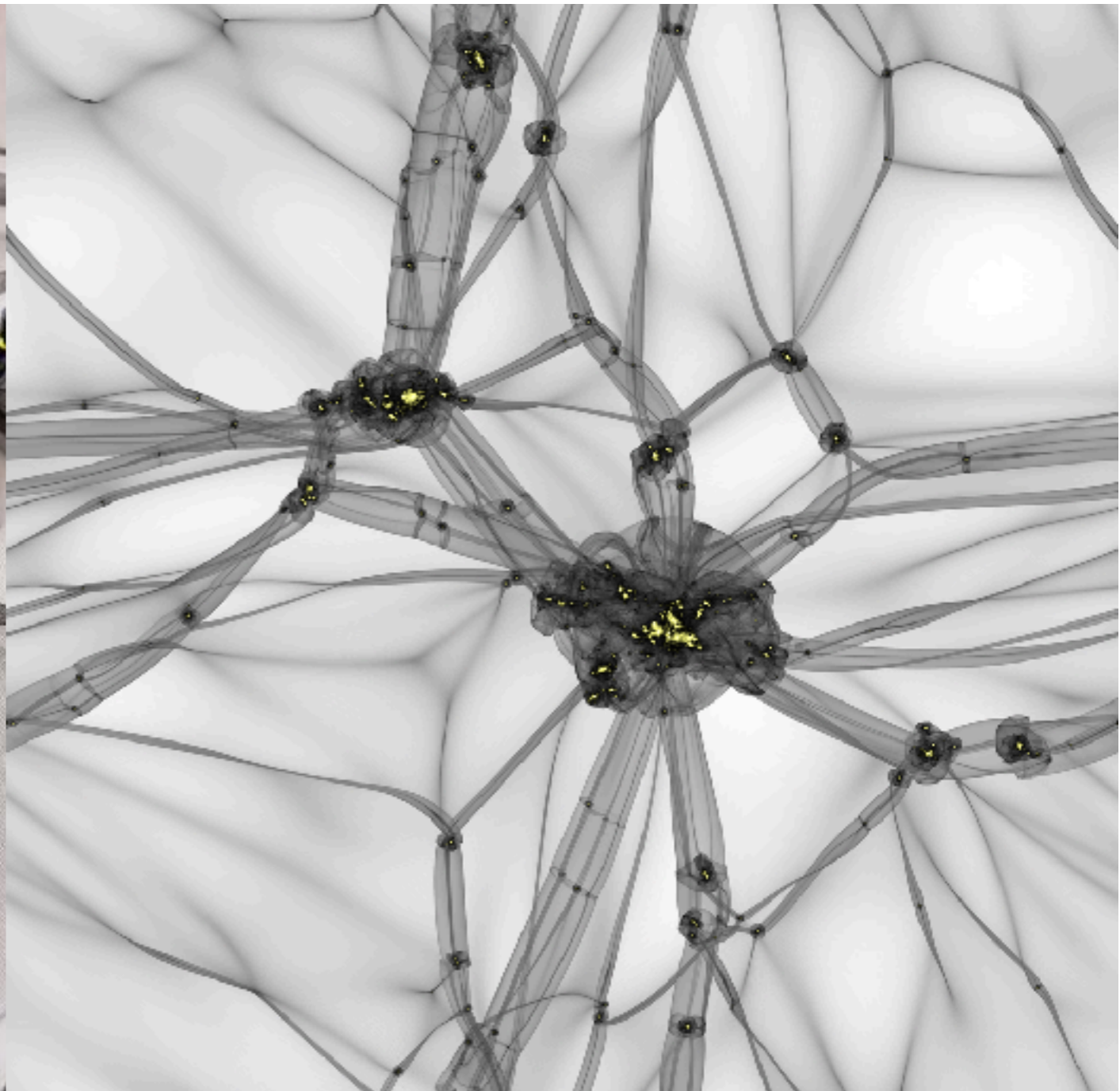
Robert Lang



Madonna Yoder



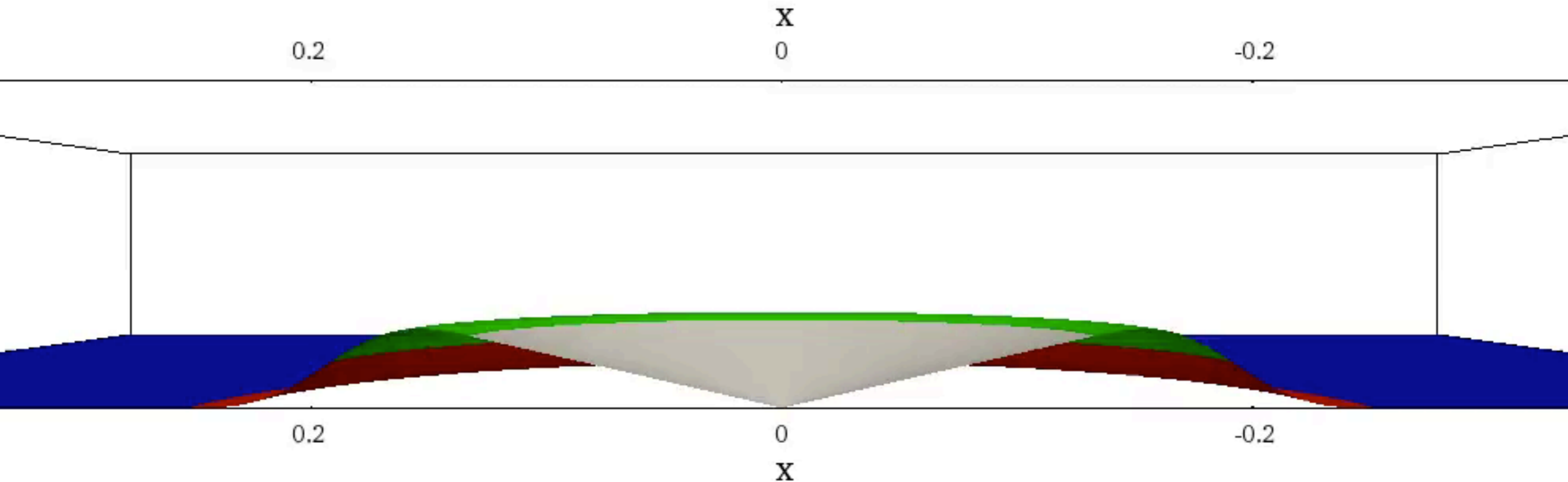
Fabric folding mimics cosmic structure



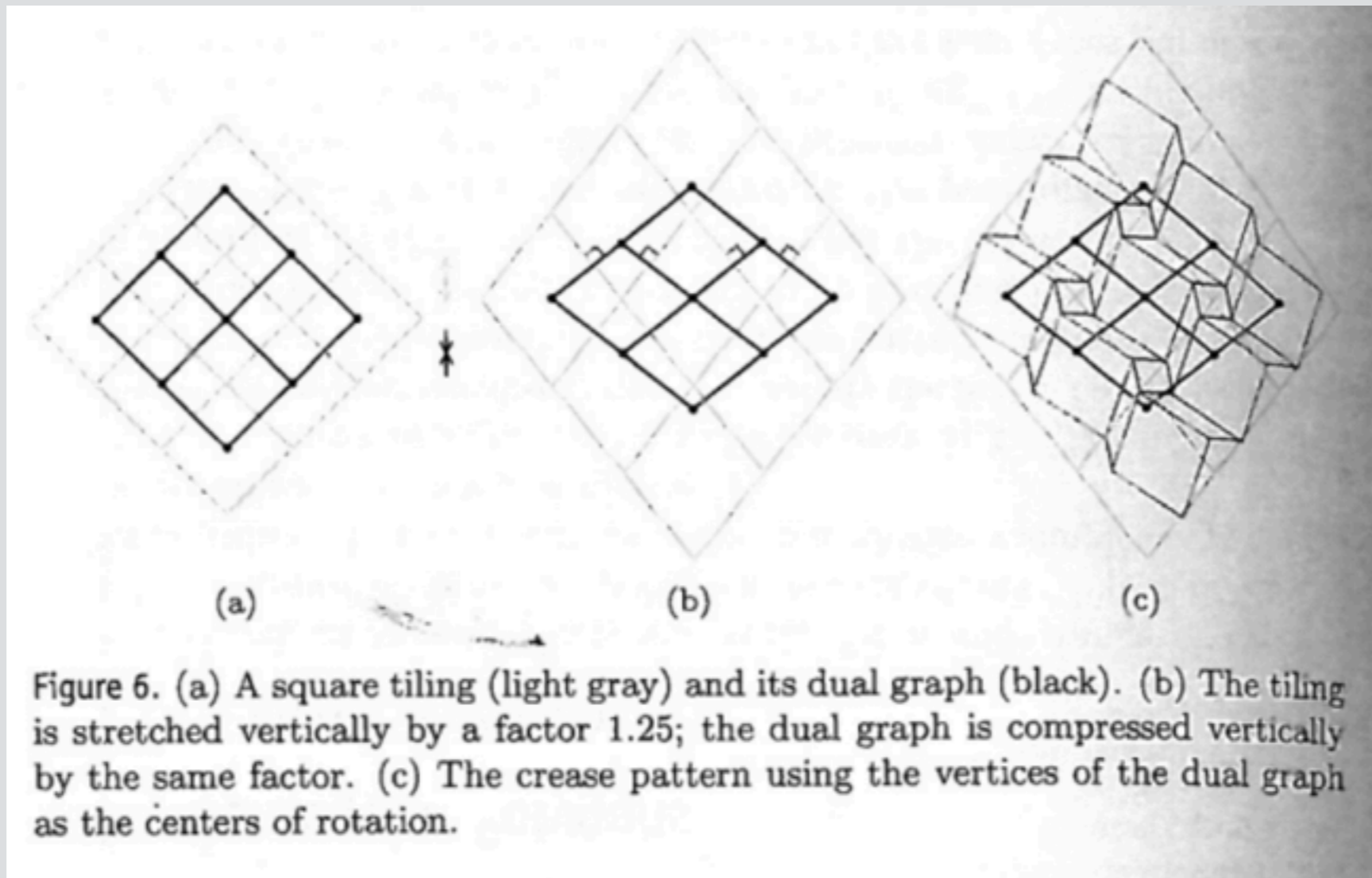
Why?

The dark-matter sheet folds in position-velocity phase space

Dark matter is collisionless — patches can pass through each other with only gravitational resistance



Lang & Bateman 2016, Origami⁶: Every Spider Web Has a Simple Flat Twist Tessellation

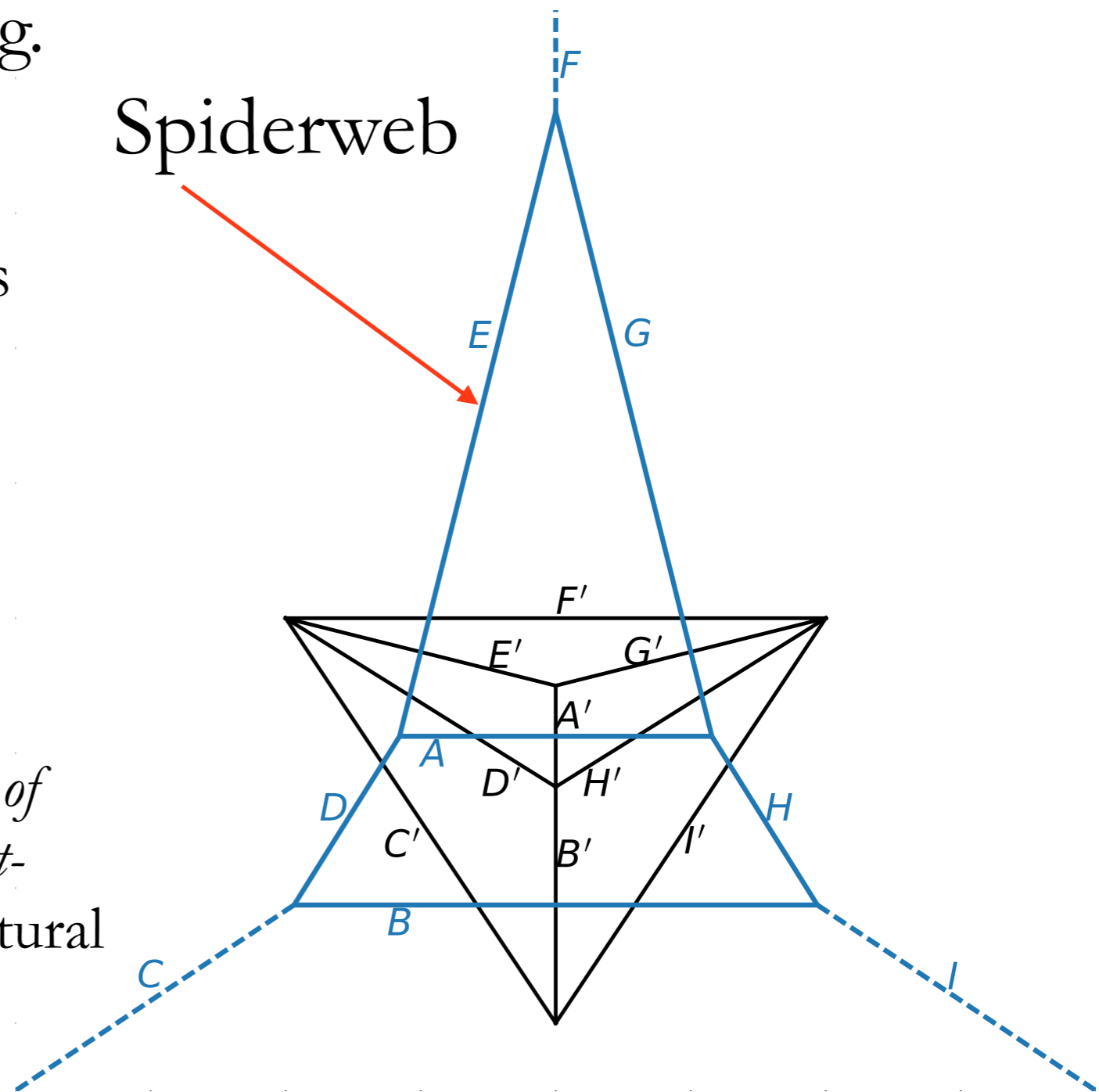


What is a “spiderweb?”

“Reciprocal dual tessellation” e.g.
Voronoi ↔ Delaunay

Graphical Statics, founded by James
Clerk Maxwell (discoverer of
electromagnetism)

Akbazardeh (2025),
Polyhedral Graphical Statics;
Baker & McRobie (2025), *The Geometry of
Equilibrium: James Clerk Maxwell and 21st-
Century Structural Mechanics*, by the structural
engineer of the Burj Khalifa, tallest
building in the world



cosmic web = origami tessellation = spiderweb

Tomás Saraceno, *14 Billions* (working title)

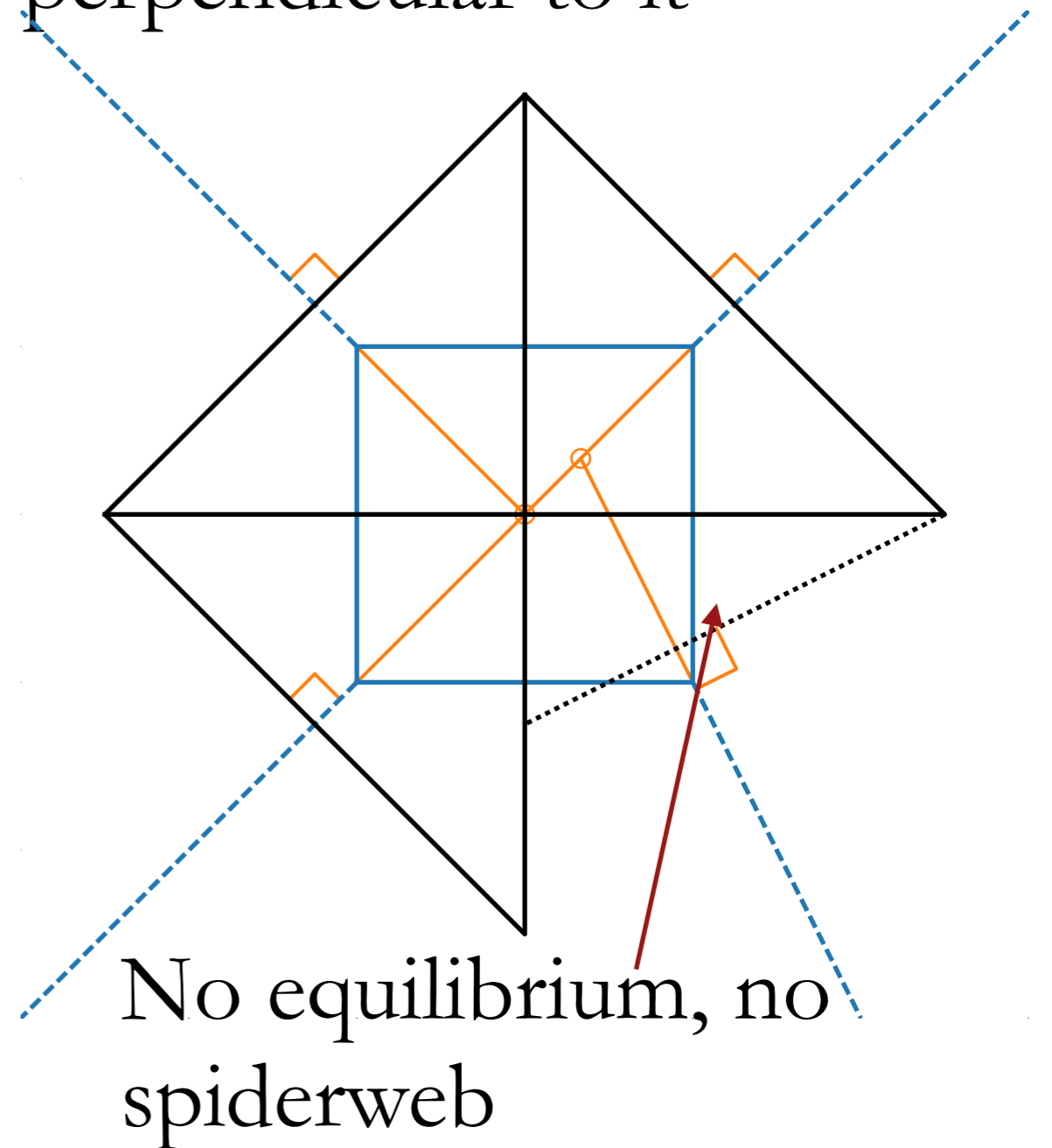
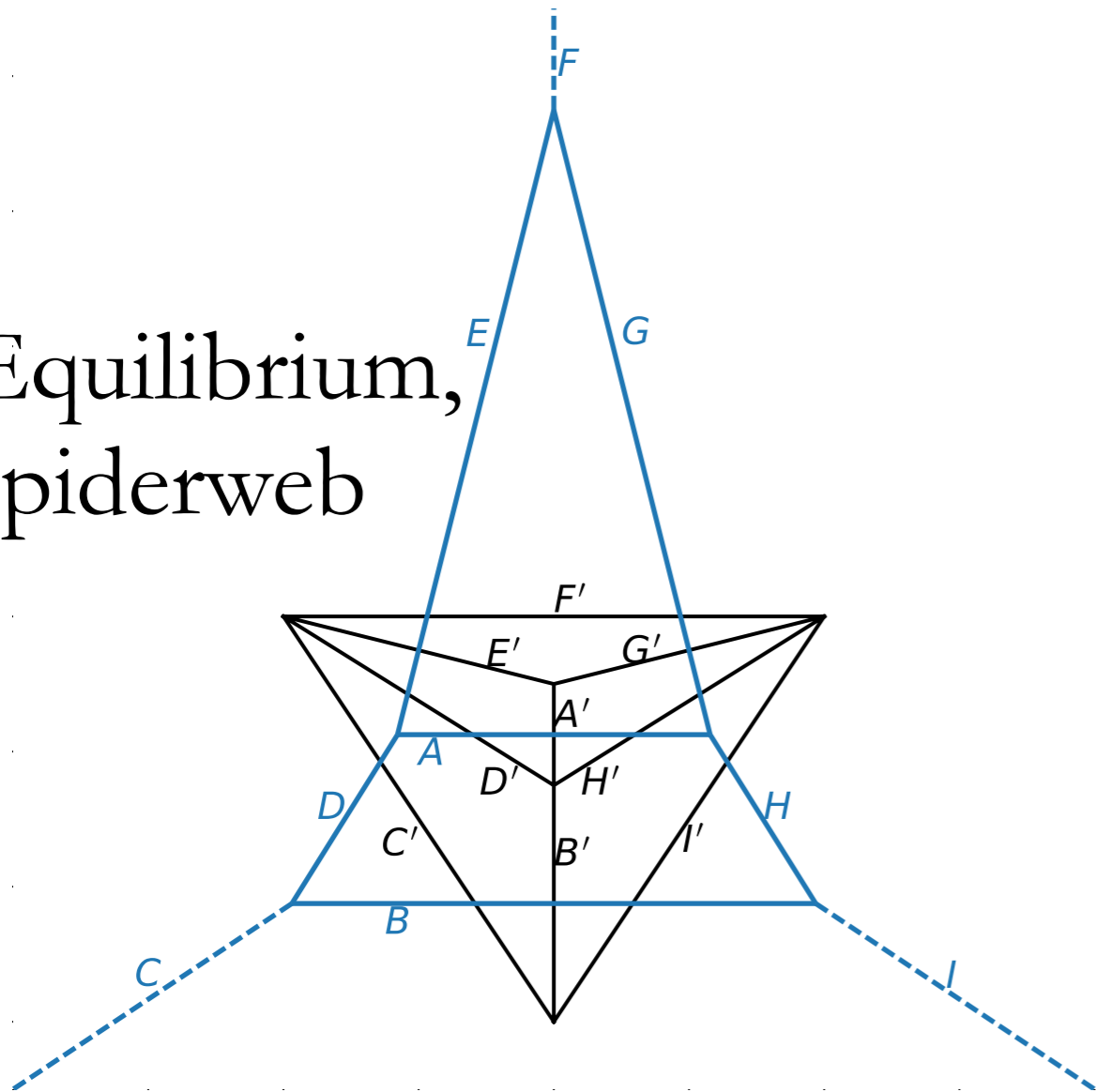


For equilibrium spiderwebs:

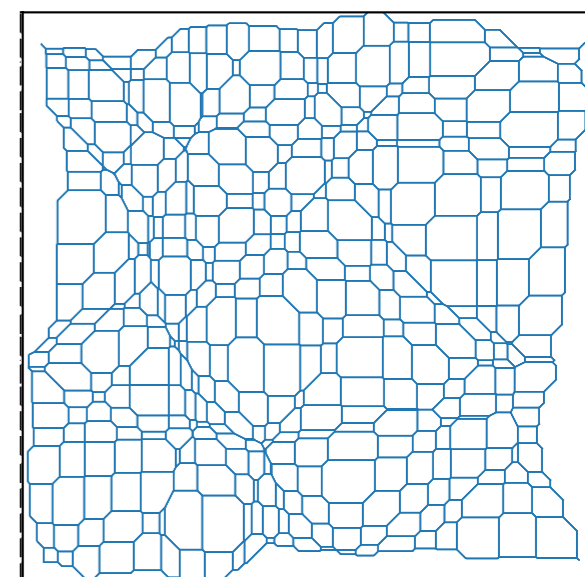
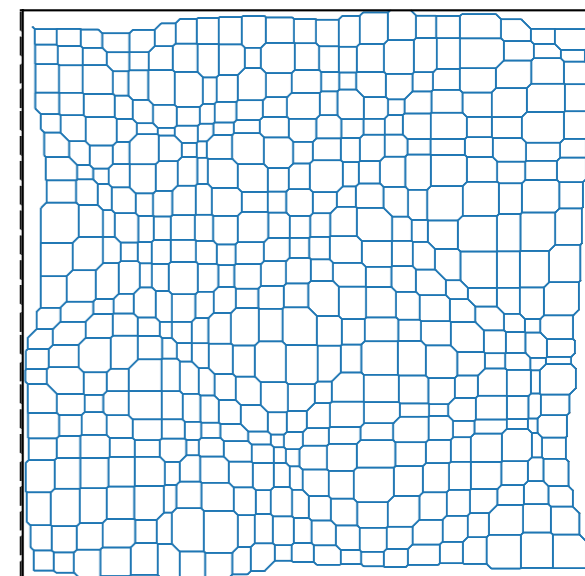
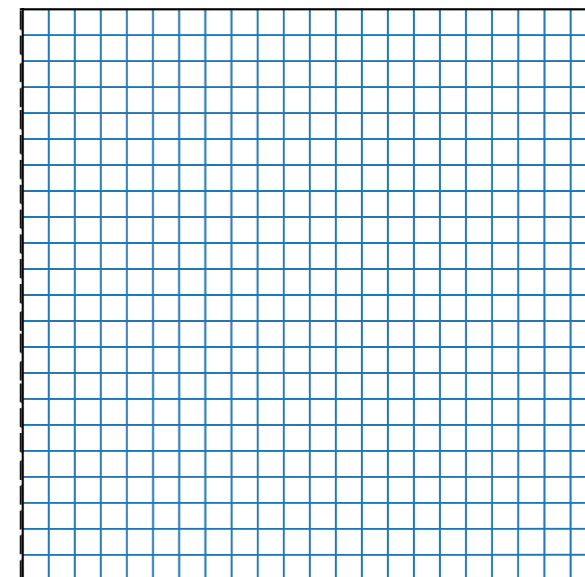
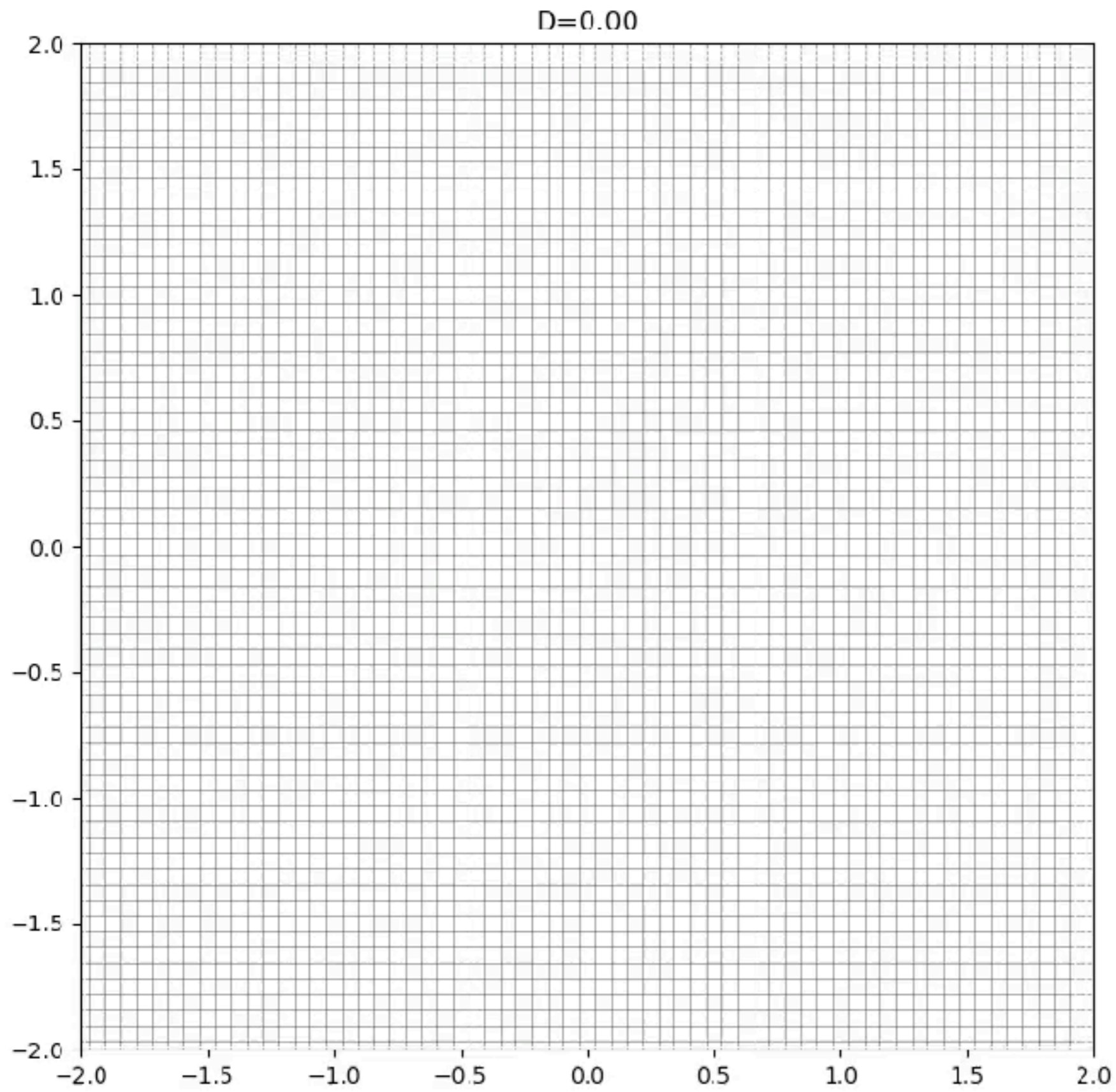
Blue: “form diagram” of all the links in an architectural network

Orange: “force diagram,” with a polygon (polyhedron in 3D) at each node of the network, proportional to force on the link perpendicular to it

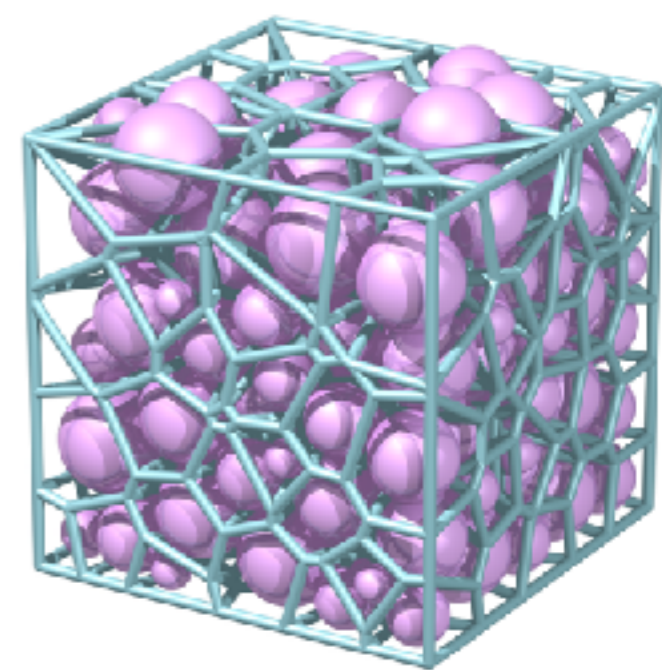
Equilibrium,
spiderweb



Same geometry used to approximate cosmological flows
(Hidding 2014; Neyrinck, Hidding et al. 2018)



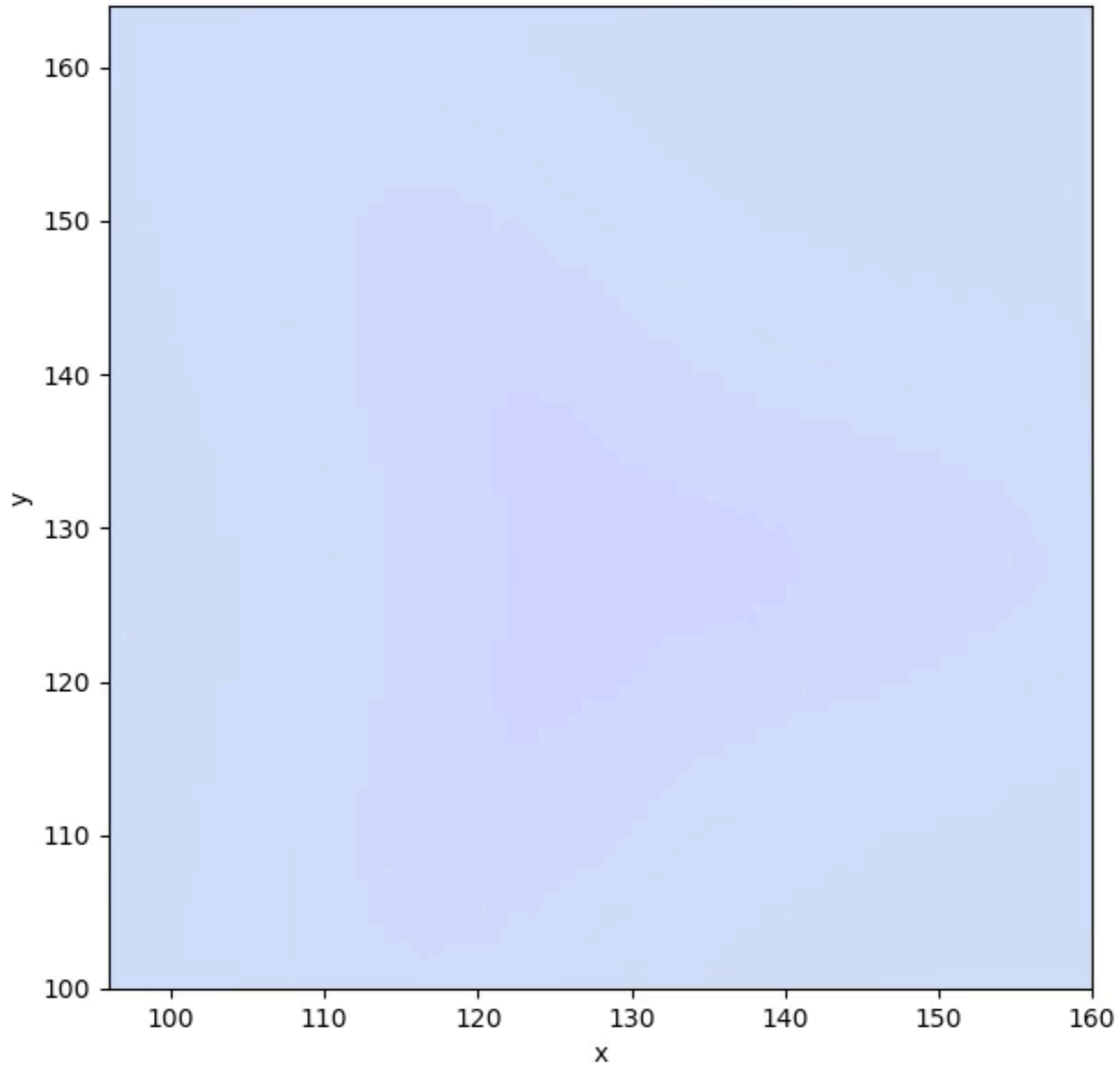
Like balloons inflating at different rates, some collapsing



BalloonArt by Sue Bowler

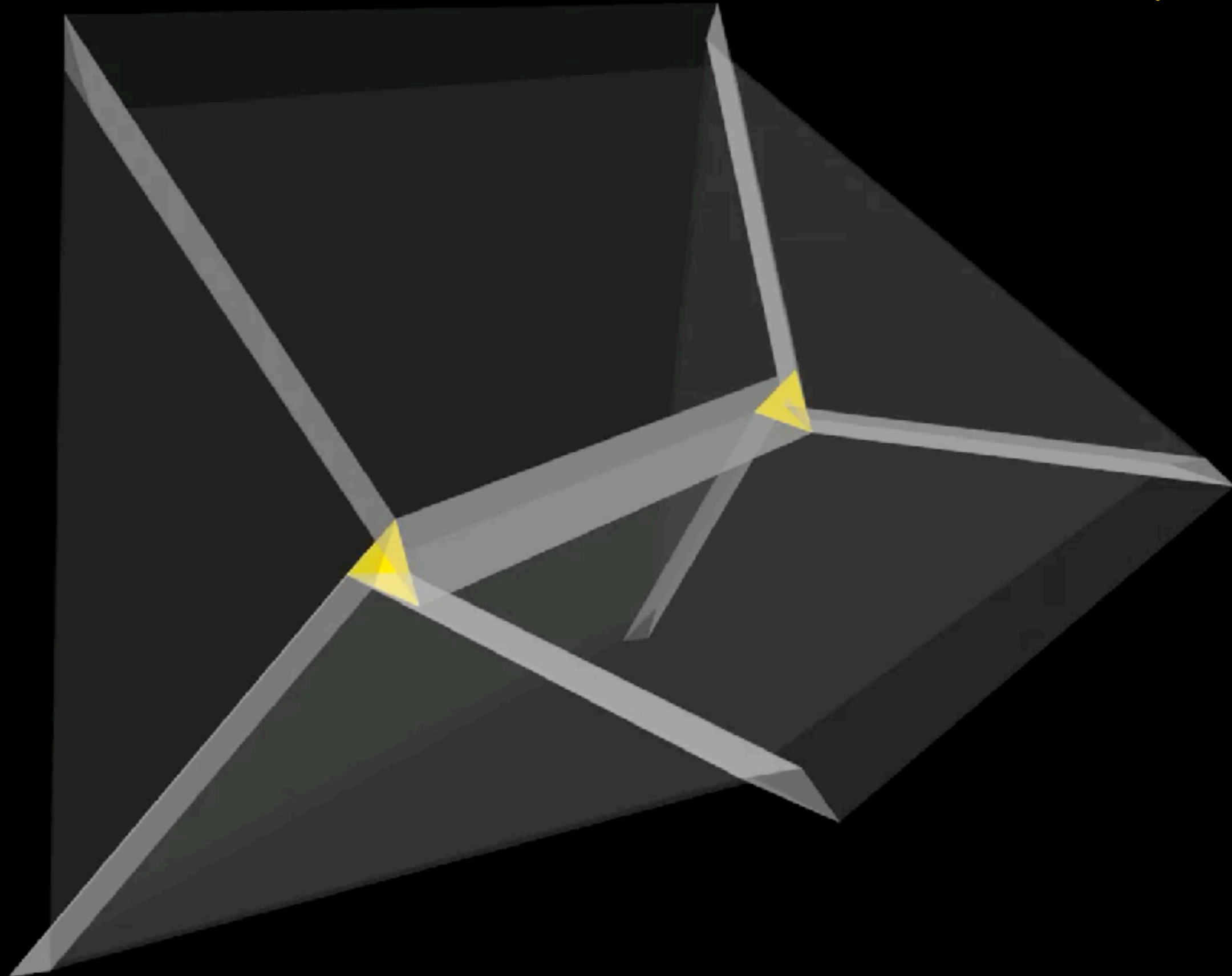
3-Propeller (twist fold)

Fold Your Own Universe Time = 0.00

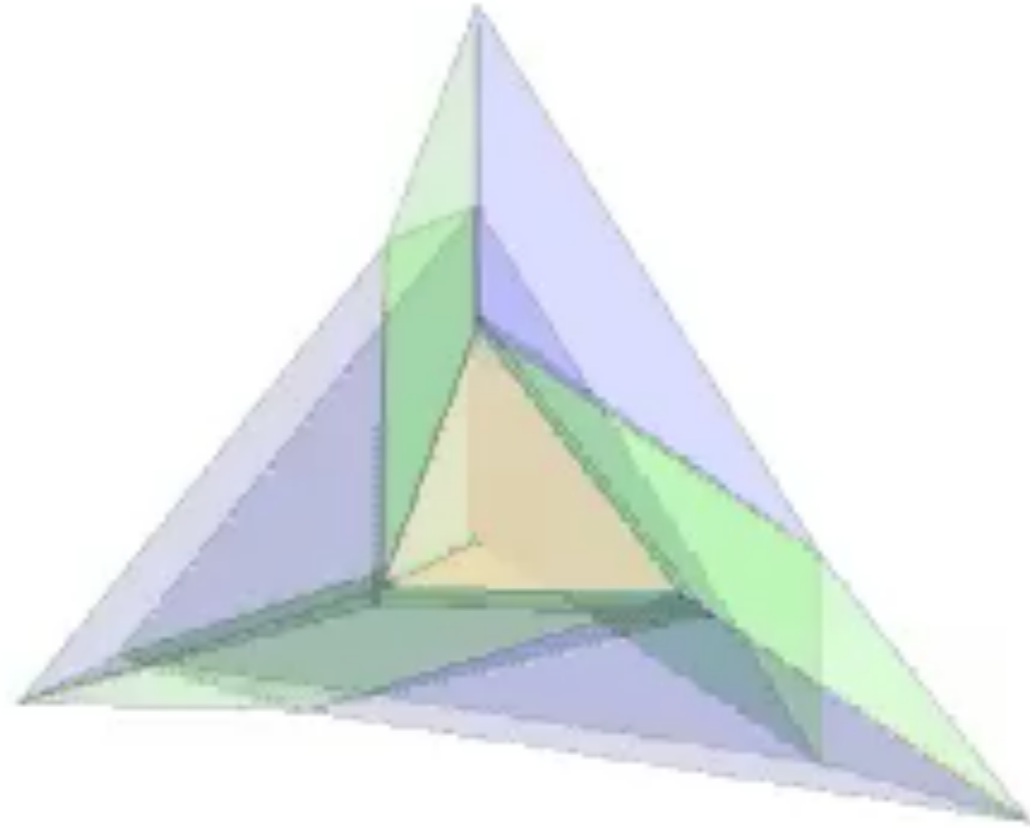


A 3D origami cosmic web

Filaments spin, linking spins of neighboring galaxies/clusters



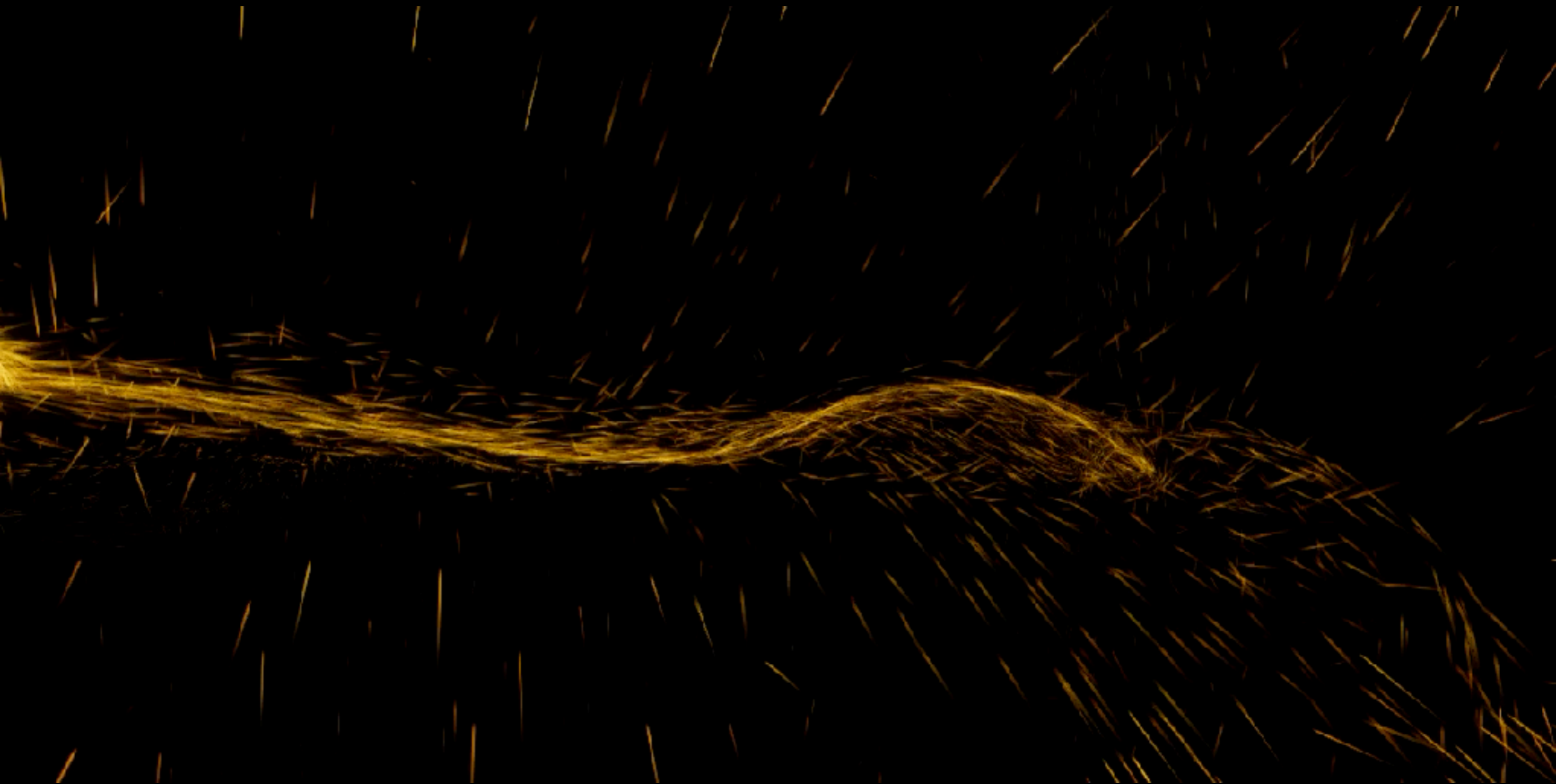
Irregular 3D twist fold



UN
FOLDED

Rotating filament!

Xia, MN, Cai & Aragón-Calvo (2021)



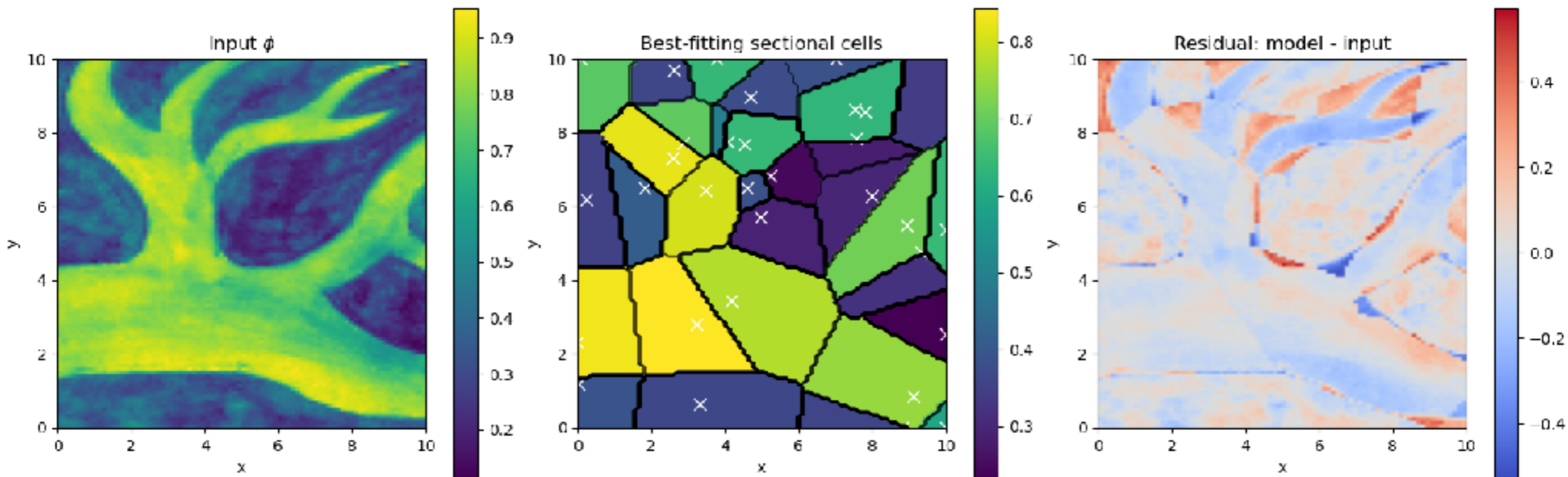


Next steps

(cosmology)

Can fit a collection of cells to a map of a potential — useful for reconstructing initial conditions, and looking at the effect of structures on the cosmic microwave background (called ISW).

Help to decide where filaments in the universe are?



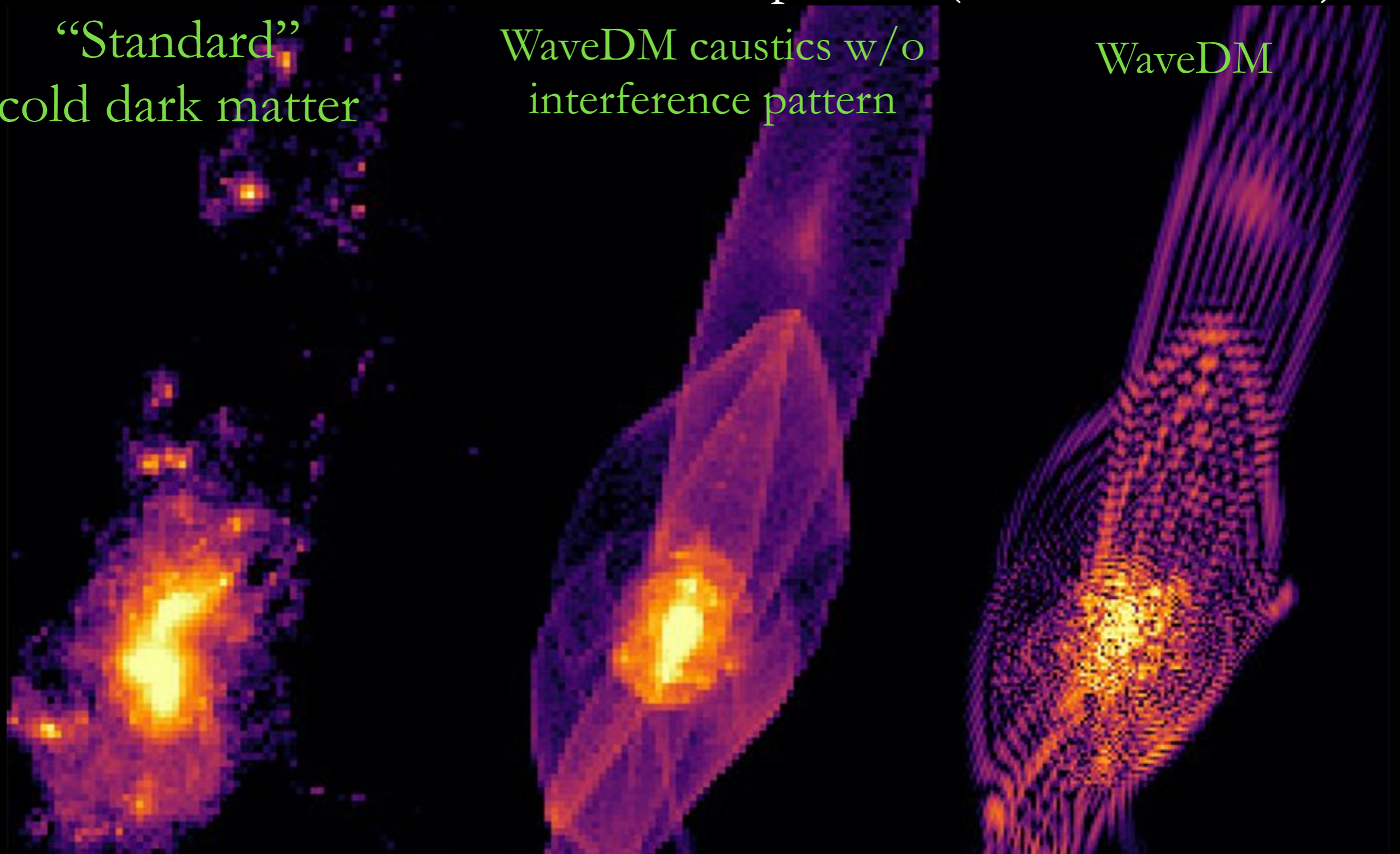
Next steps (cosmology)

“Moirégami,” painting the dark-matter sheet with superfluid wave dark matter phases. Shine a light through the structure to see interference pattern (Mocz et al. 2019)

“Standard”
cold dark matter

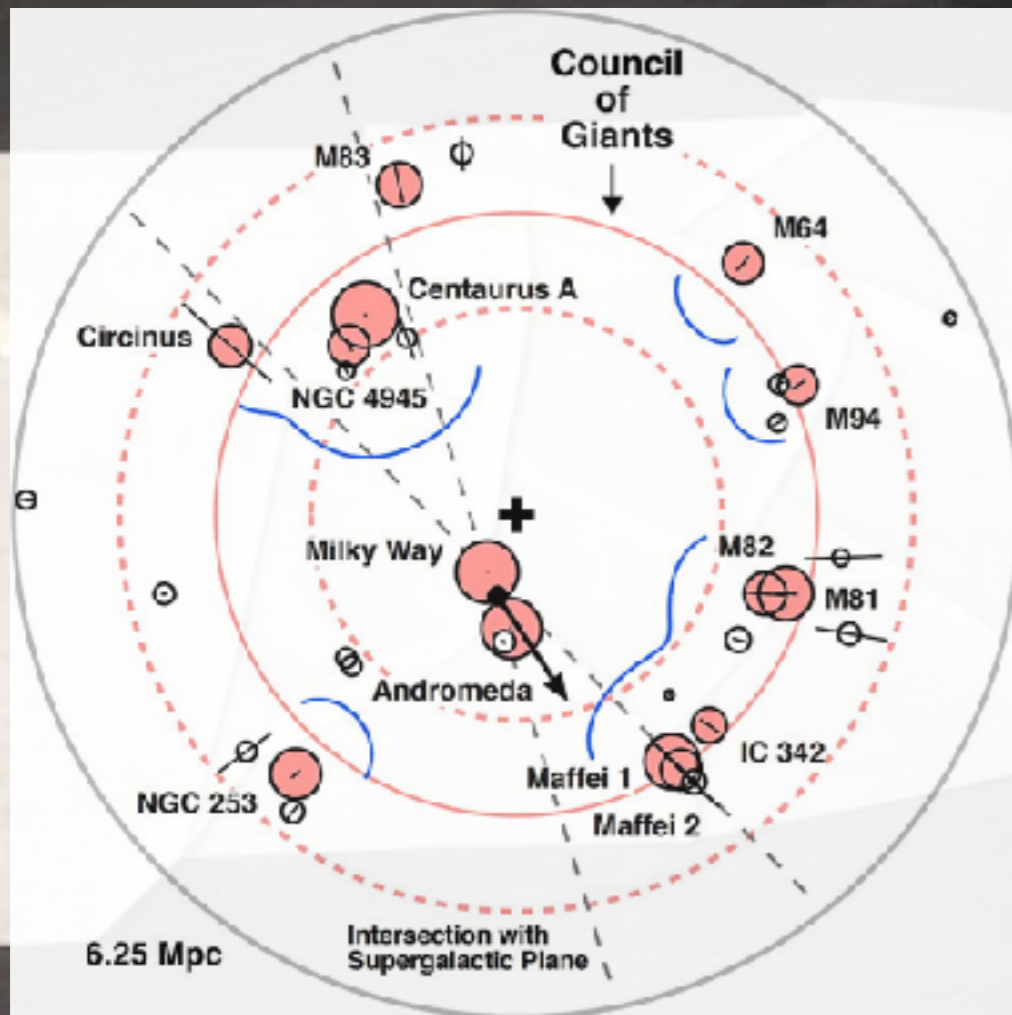
WaveDM caustics w/o
interference pattern

WaveDM



Next steps (art)

Use fast sectional-Voronoi software to design optimal patterns to make origami tilings and dreamcatchers with a certain form





Conclusions

- Tessellation concepts essential and beautiful tools in nature, art
- can connect the cosmic web to flow processes: river networks, even circulatory systems in our body