

BISTABLE AUXETIC SURFACE STRUCTURES

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ACM TRANSACTIONS ON GRAPHICS, 2021

TIAN CHEN

GEOMETRIC COMPUTING LABORATORY
FLEXIBLE STRUCTURES LABORATORY





Sam Poincloux

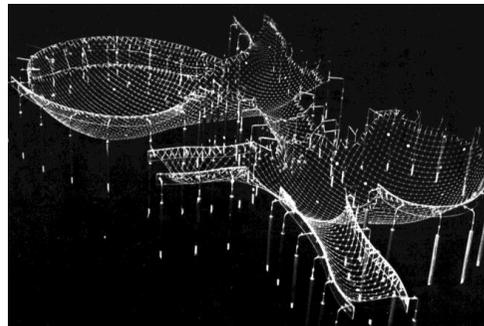
DEPLOYABLE STRUCTURES

Regular pattern
Simple boundary



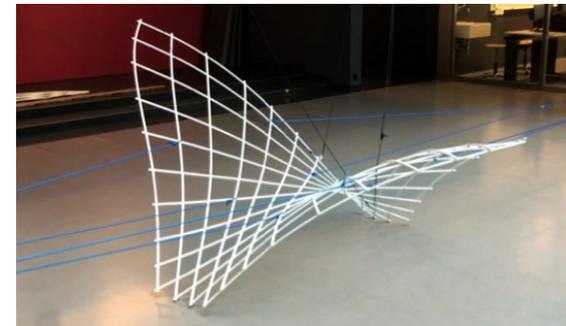
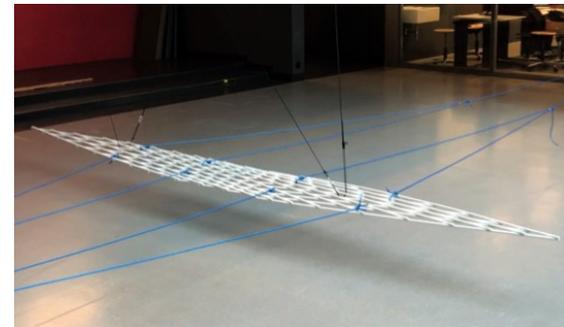
https://en.wikipedia.org/wiki/Deployable_structure

Regular pattern
Complex boundary



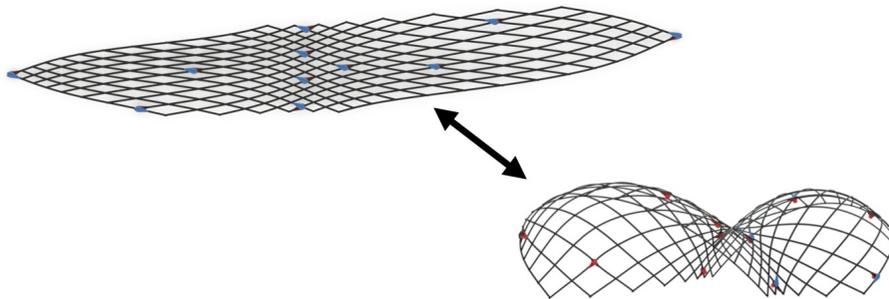
<https://www.architectsjournal.co.uk/competitions/competition-mannheim-multihalle-germany>

Optimized pattern
Simple boundary

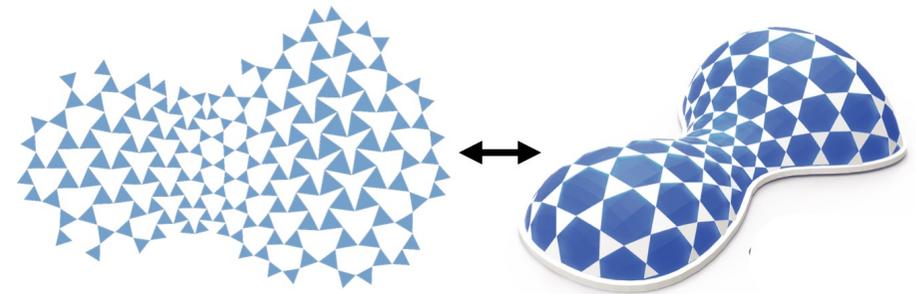


Panetta, J., et al., ACM Transactions on Graphics, 2019

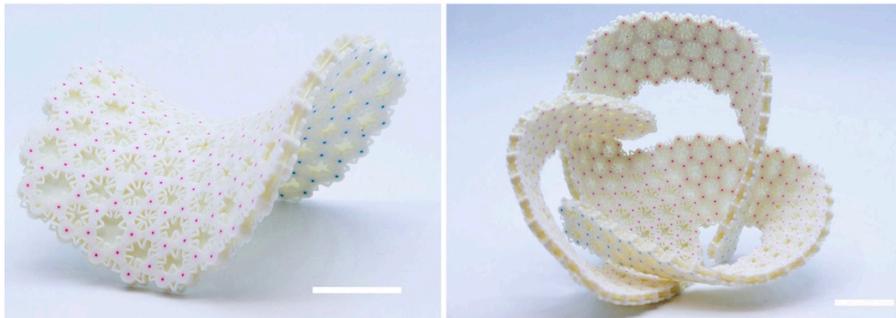
CHALLENGES



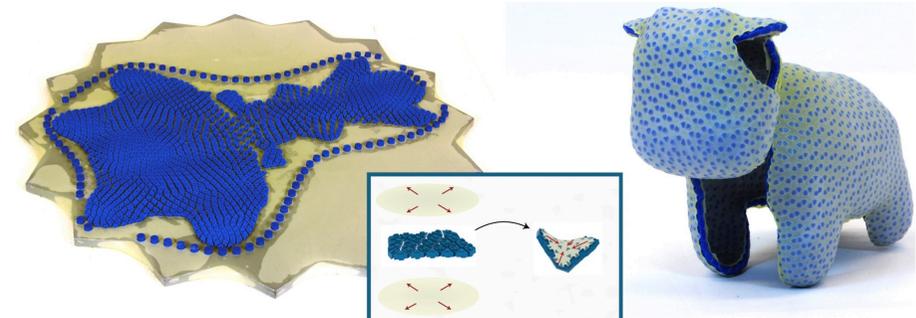
Panetta, Julian, et al. ACM Transactions on Graphics (TOG) 38.4 (2019): 1-15.



Konaković-Luković, Mina, et al. ACM Transactions on Graphics (TOG) 37.4 (2018): 1-13.

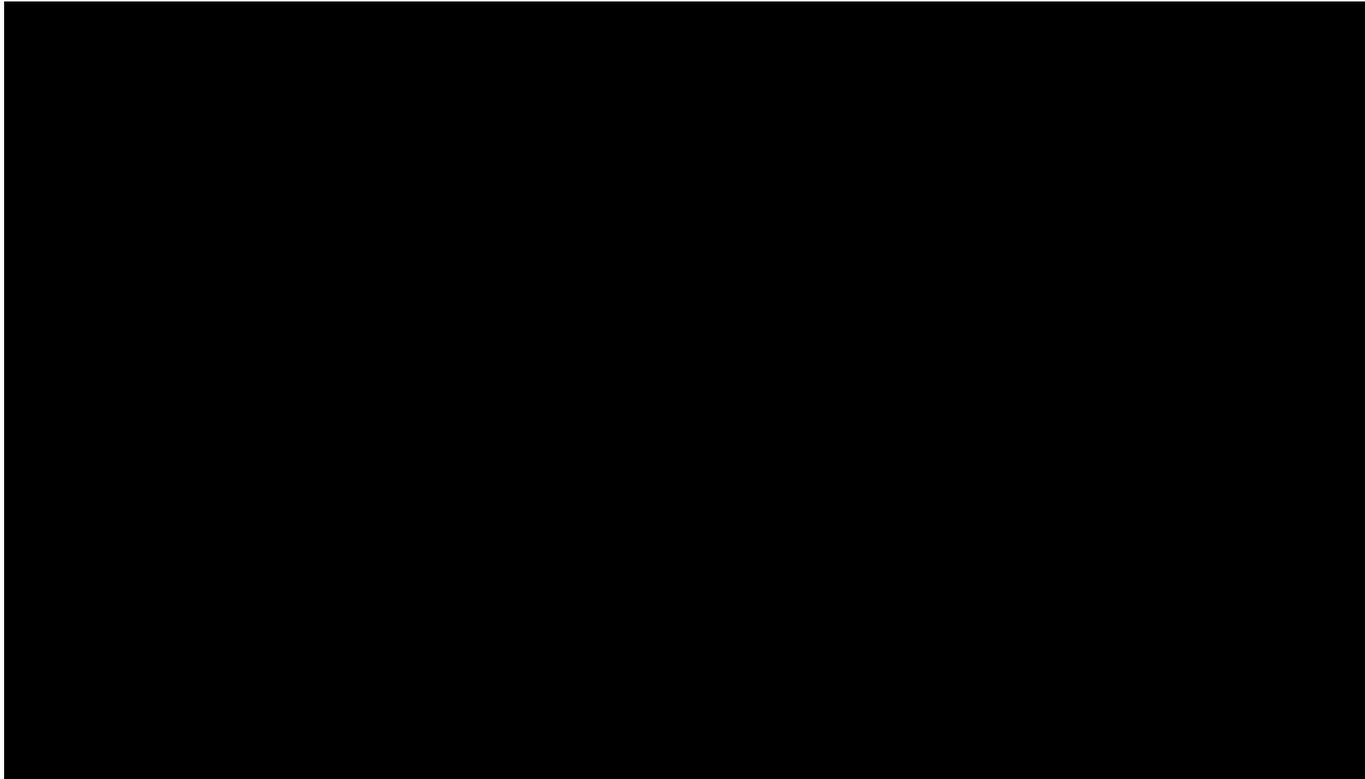


Guseinov, Ruslan, et al. Nature communications 11.1 (2020): 1-7.



Guseinov, Ruslan, et al., ACM Transactions on Graphics (TOG) 36.4 (2017): 1-12.

LINKAGE AUXETIC DEPLOYABLES

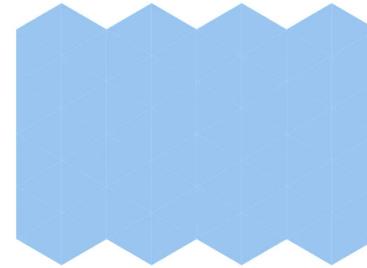
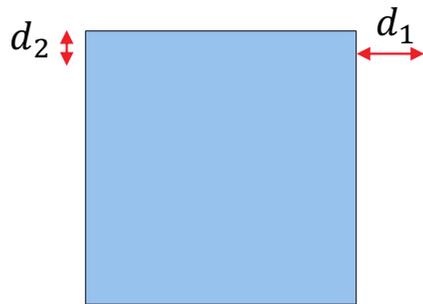


Konaković-Luković, Mina, et al. ACM Transactions on Graphics (TOG) 37.4 (2018): 1-13.

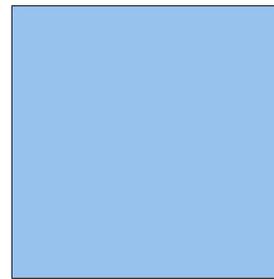
AUXETICS



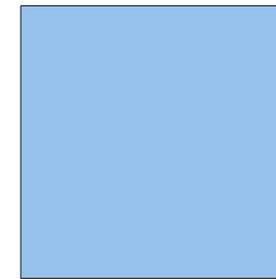
$$\nu \approx -\frac{d_2}{d_1} > 0$$



$$\nu < 0$$



$$\nu = -1, d_1 = d_2$$

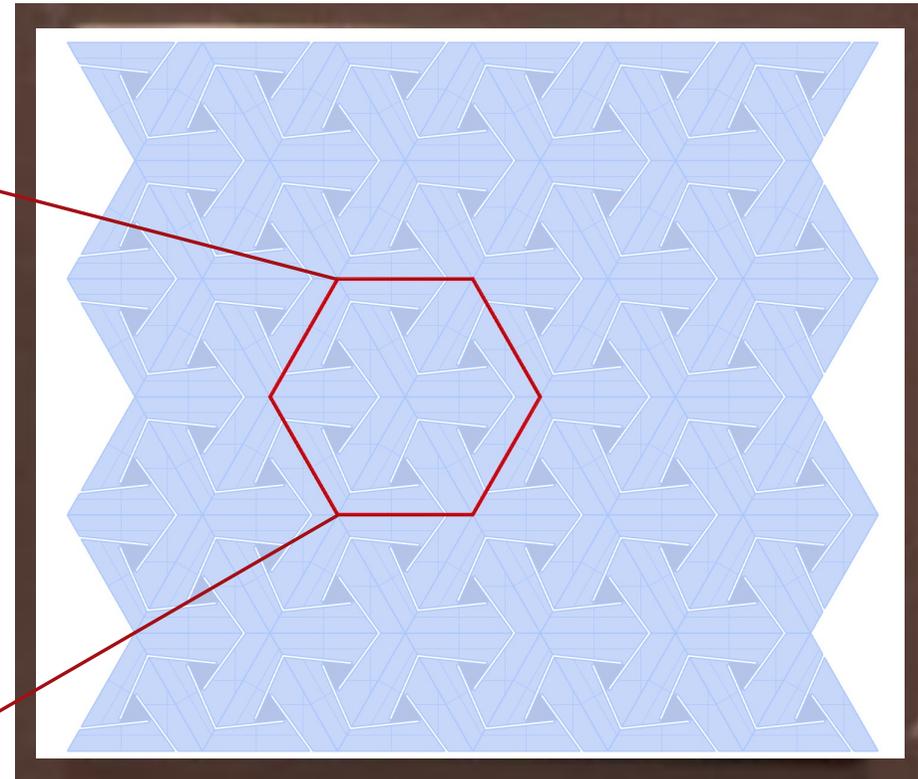
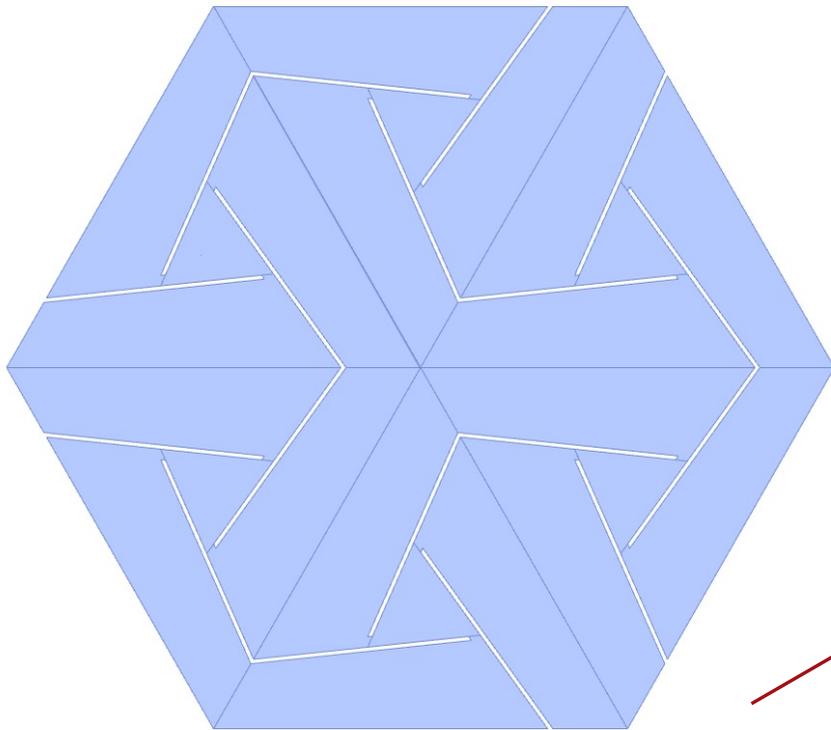


LINKAGE AUXETIC AND BISTABLE AUXETIC

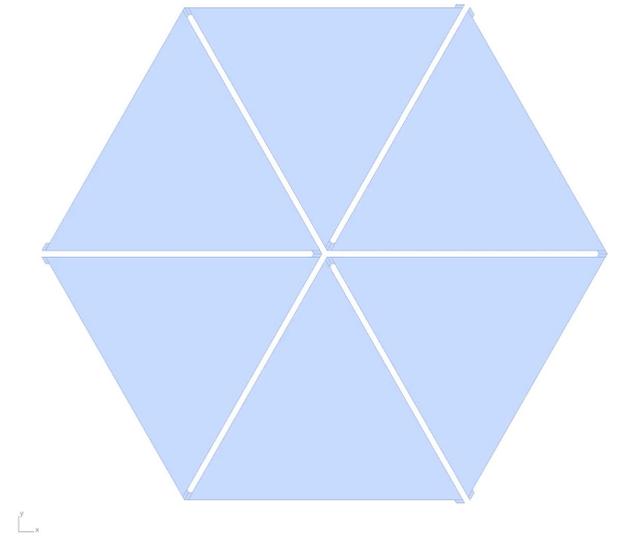
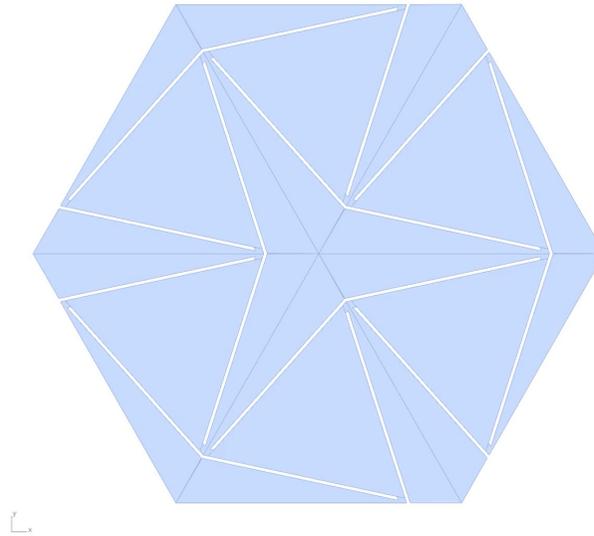
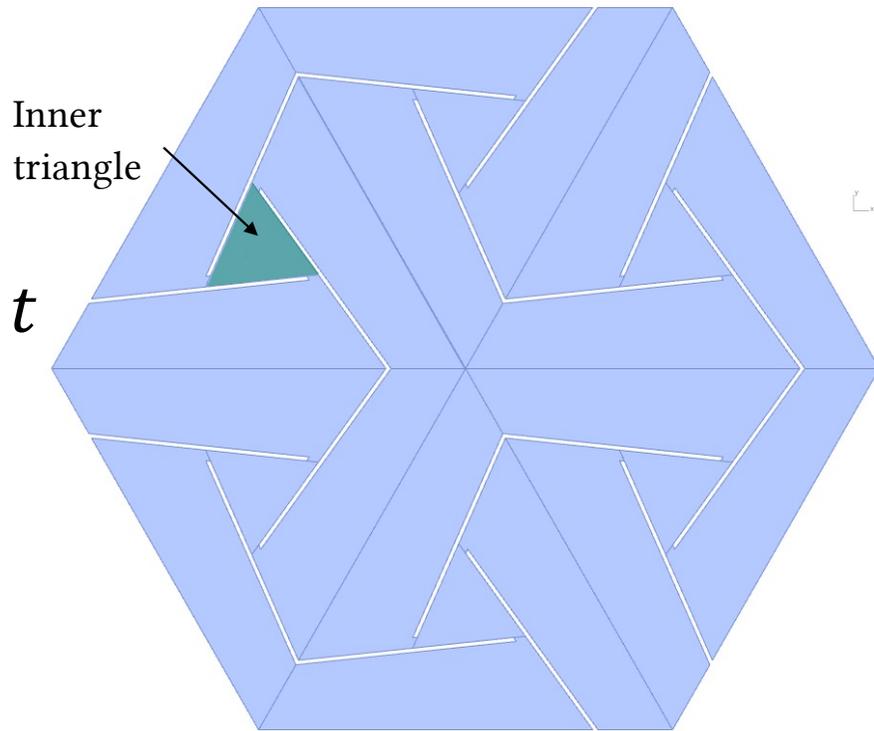


Rafsanjani, A., et al. EML 9 (2016): 291-296.

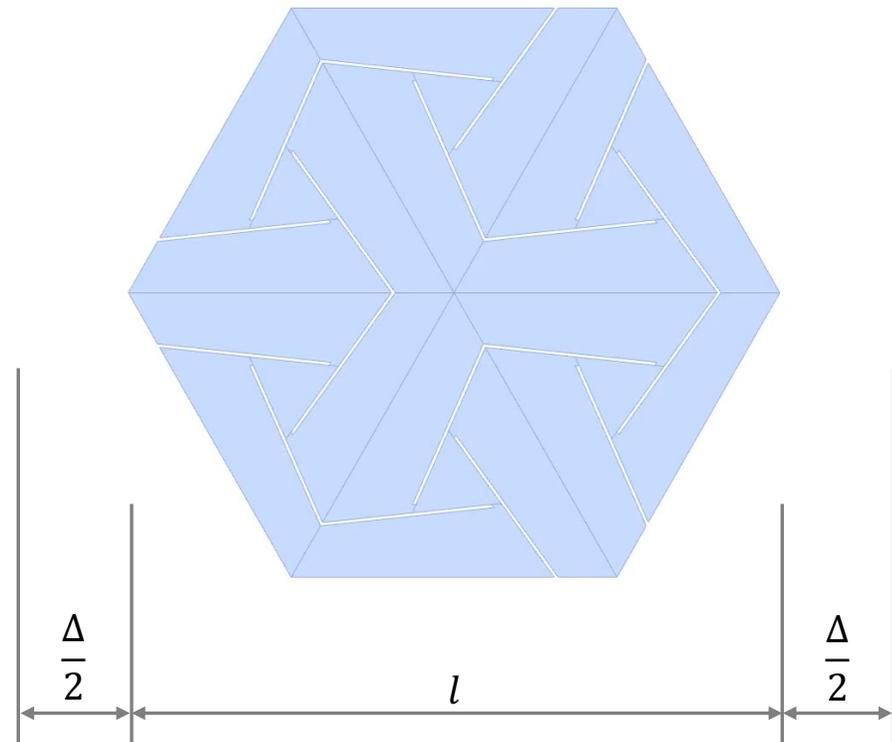
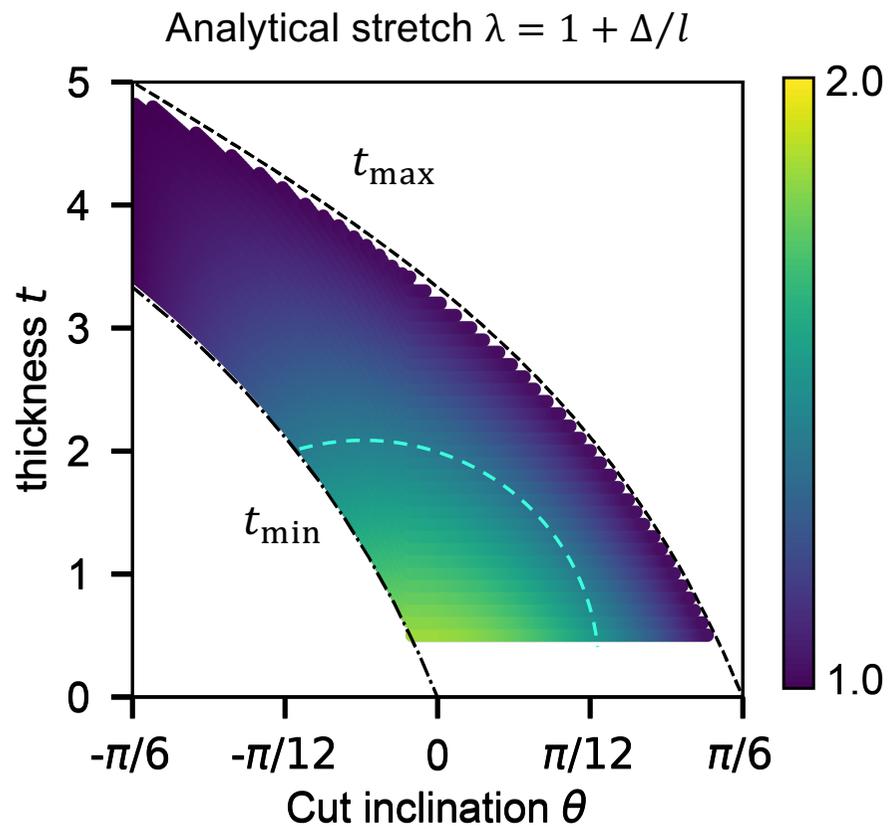
UNIT CELL



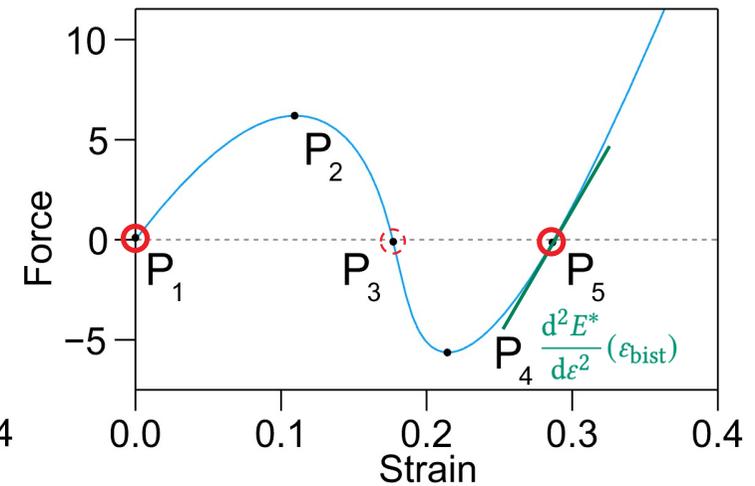
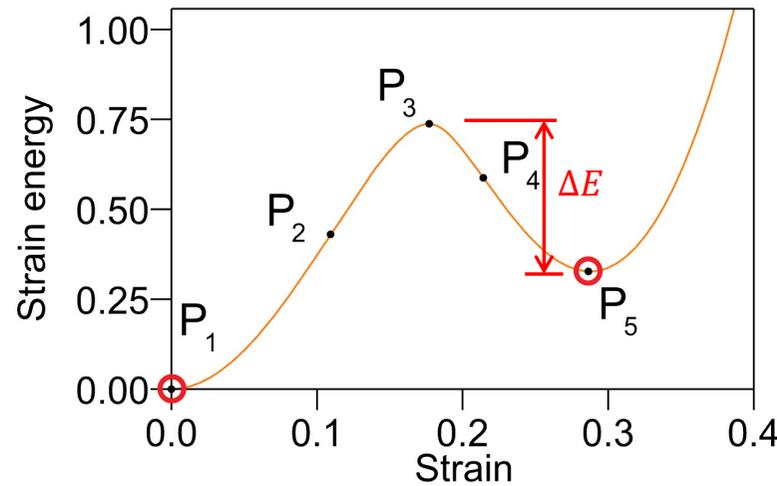
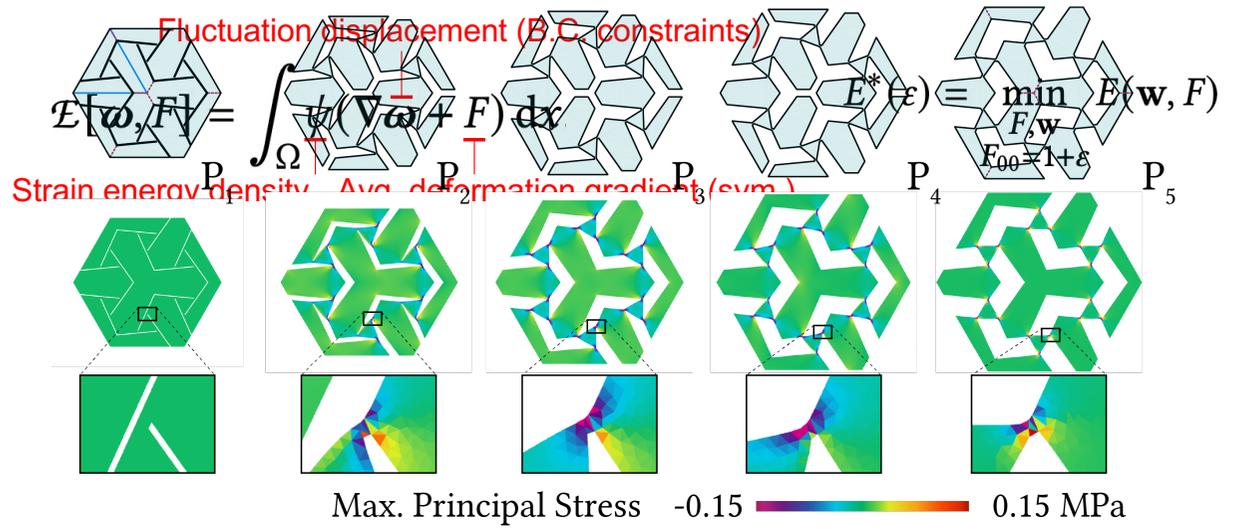
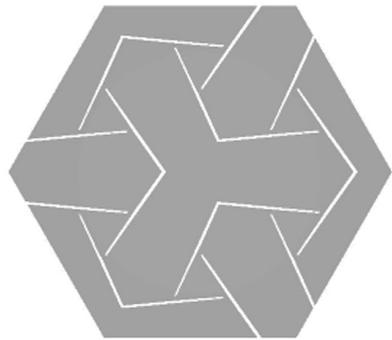
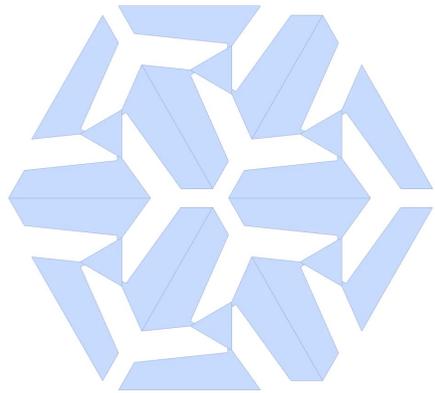
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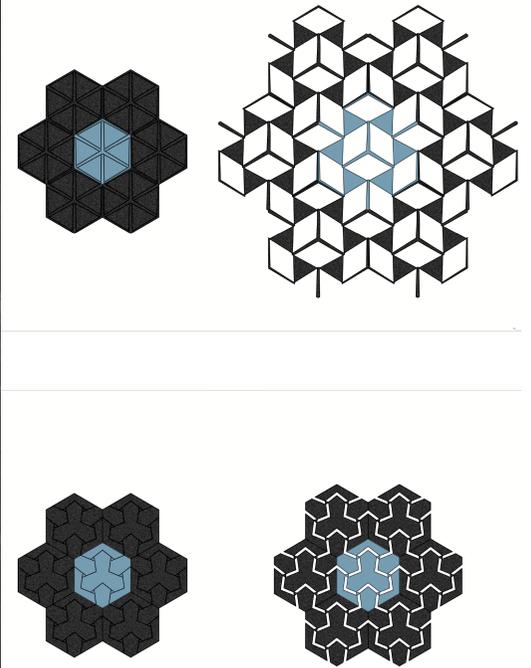
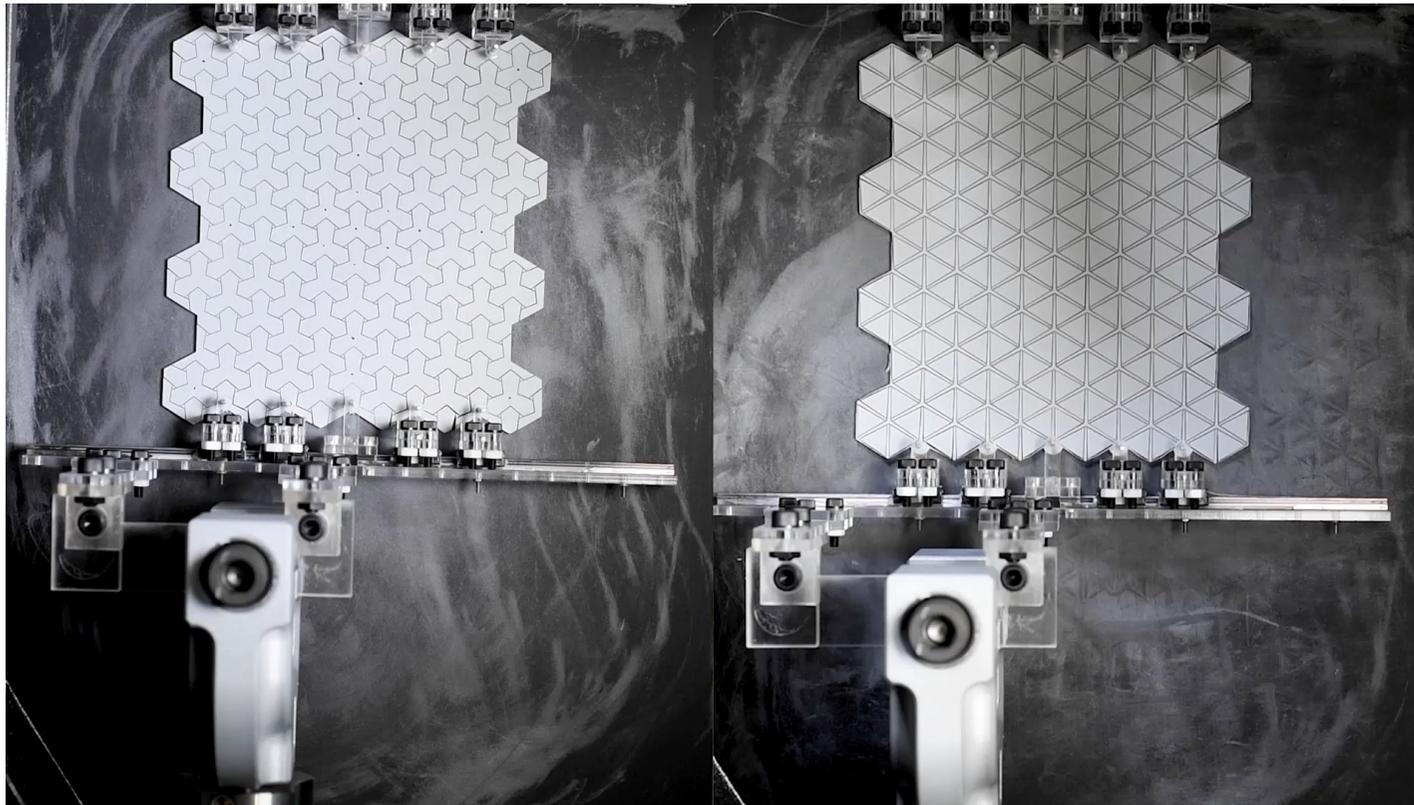
UNIT CELL KINEMATICS



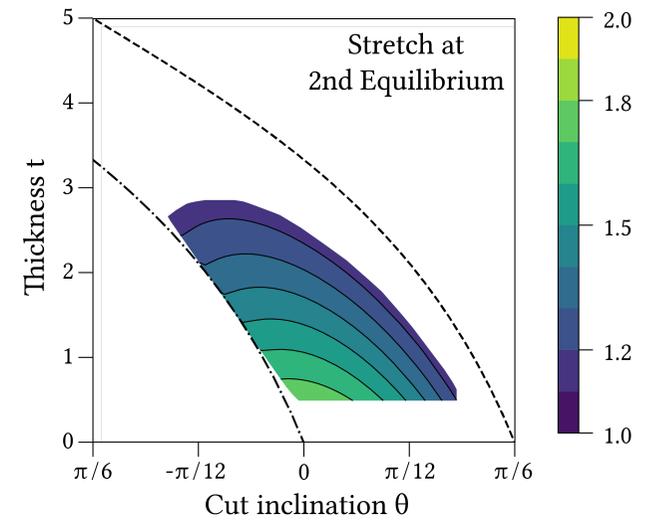
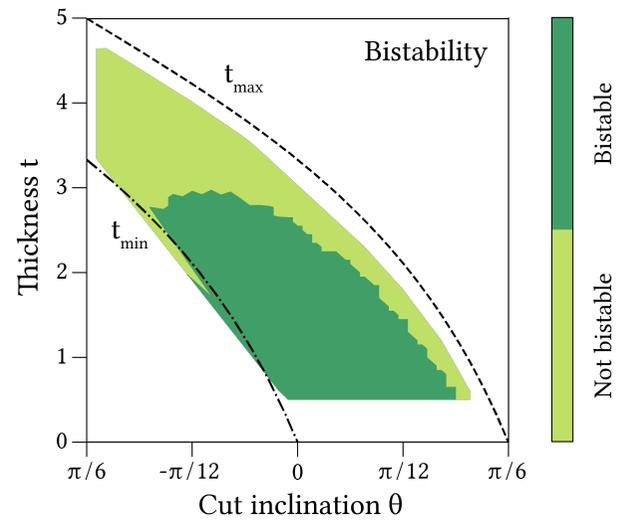
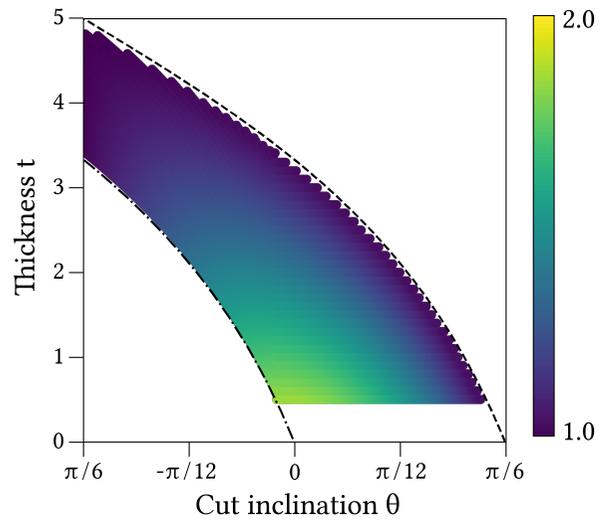
UNIT CELL MECHANICS



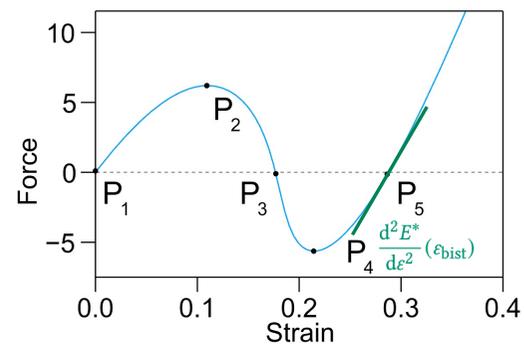
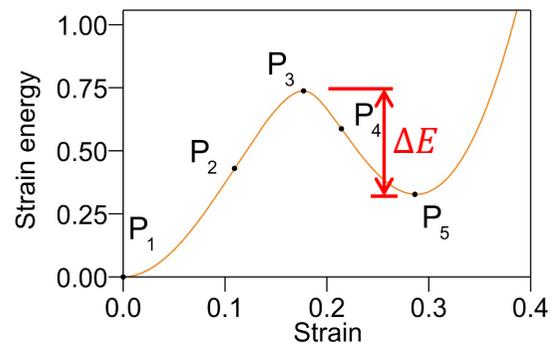
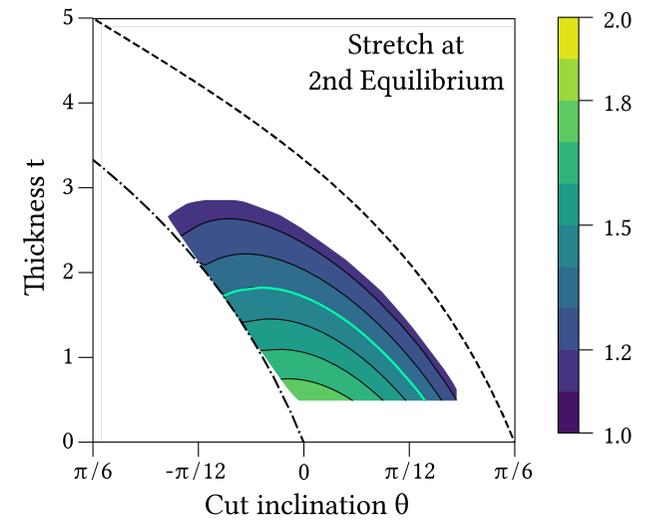
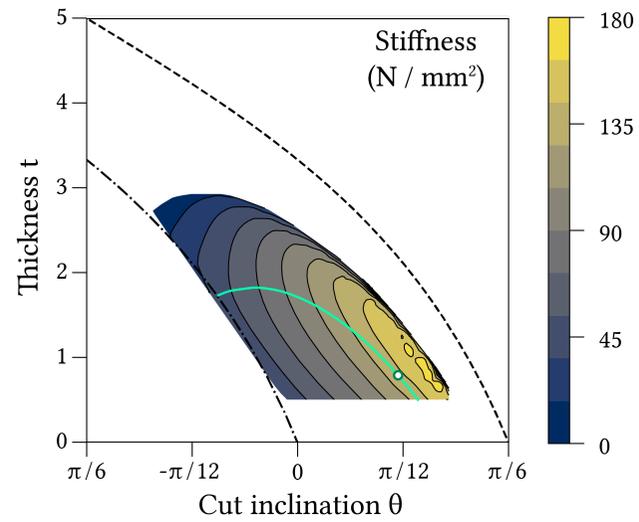
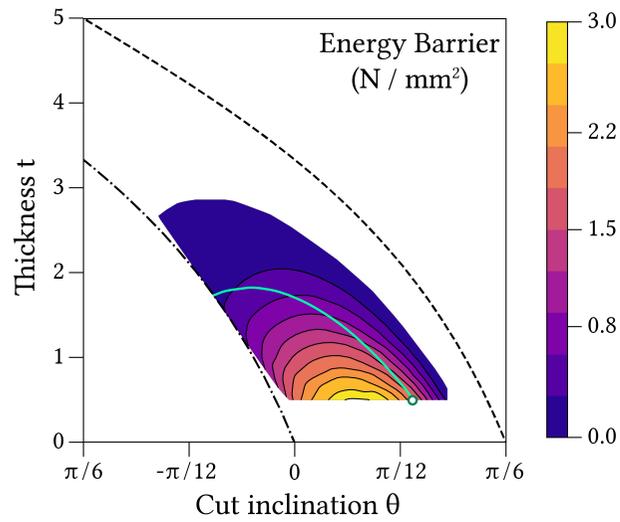
UNIT CELL SIMULATION VALIDATION



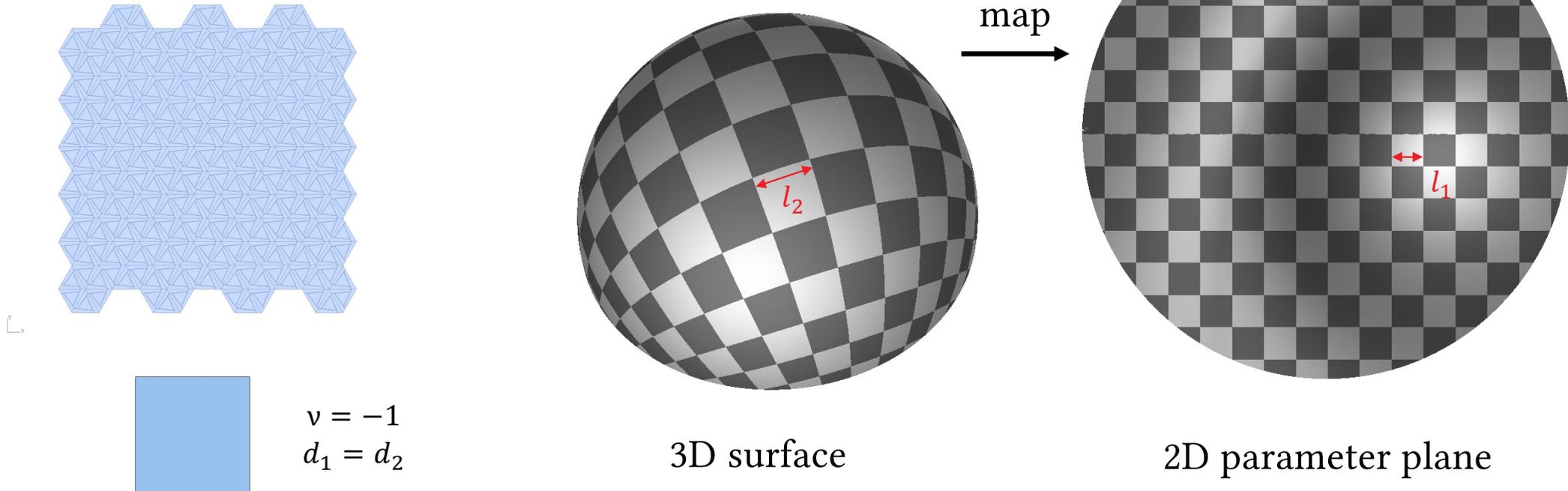
UNIT CELL RESULTS



UNIT CELL RESULTS

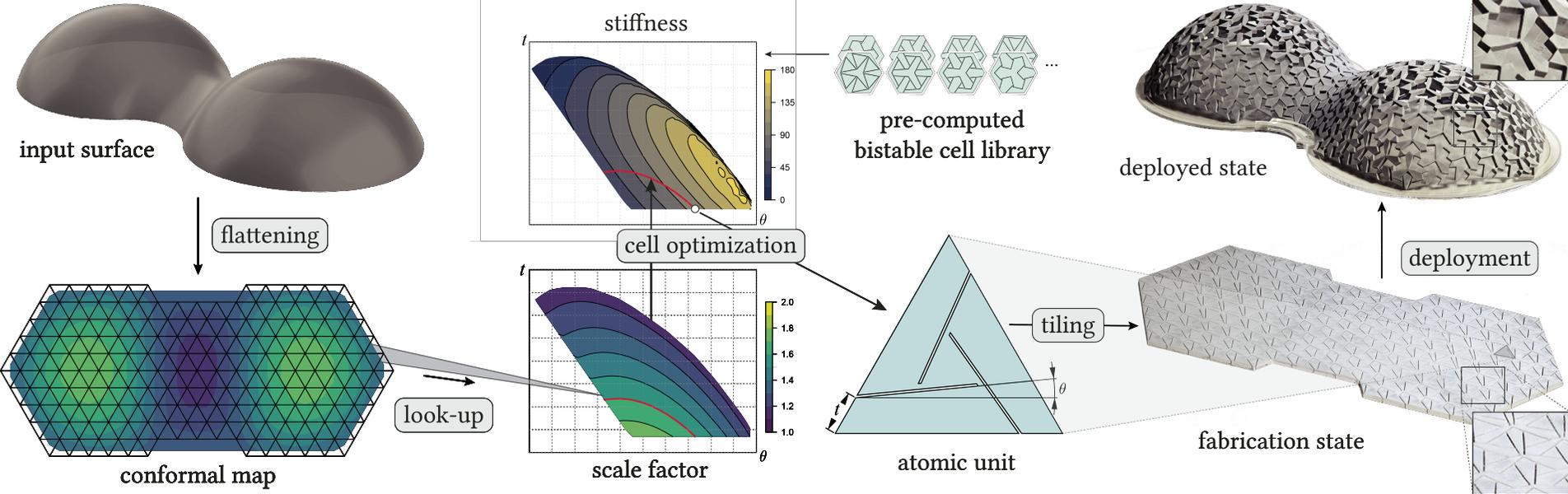


CONFORMAL MAPPING

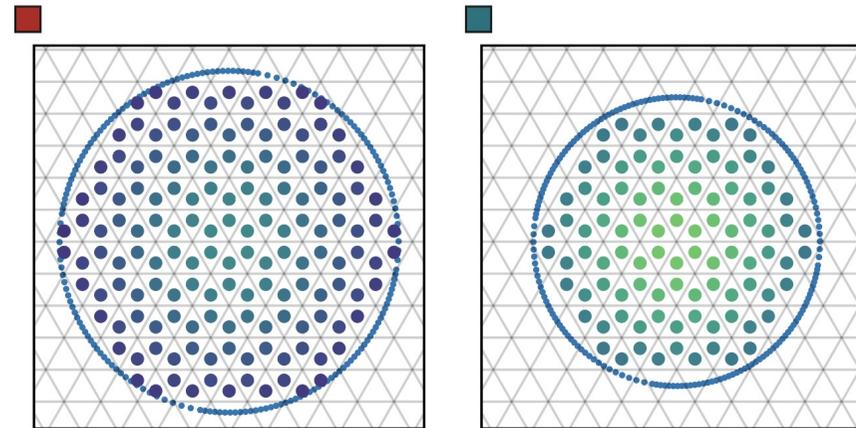
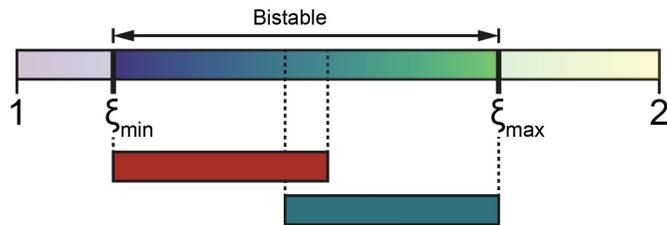
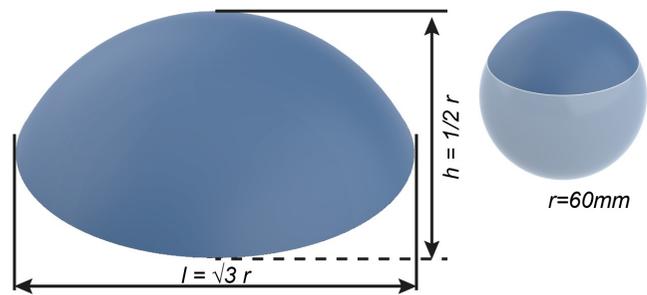


Sawhney, R., & Crane, K. (2017). *ACM Transactions on Graphics (ToG)*, 37(1), 1-14.

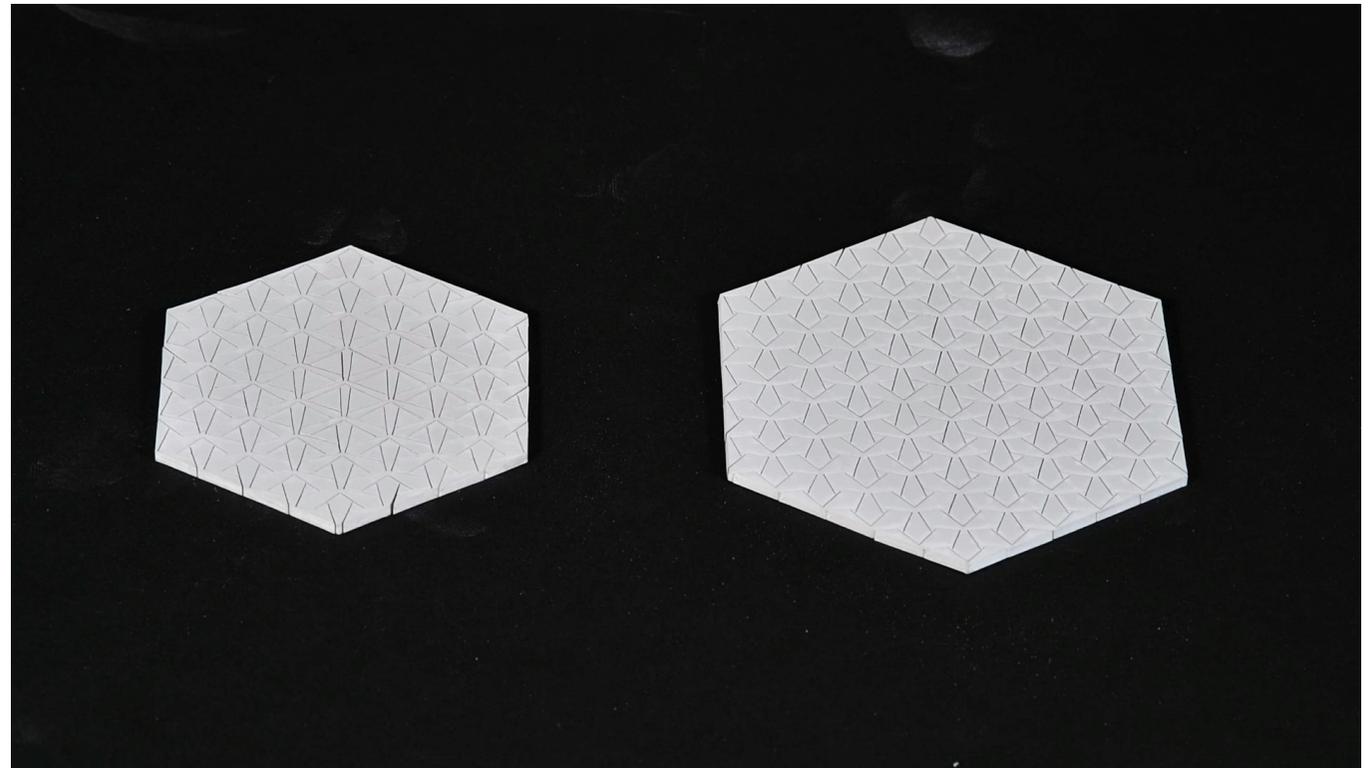
DESIGN PIPELINE



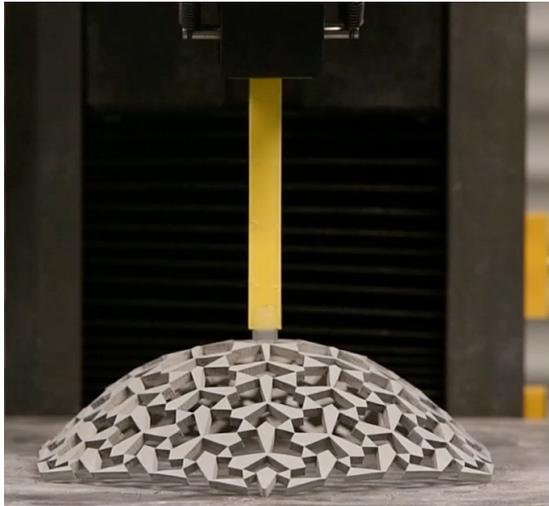
DESIGN OF A SPHERICAL CAP



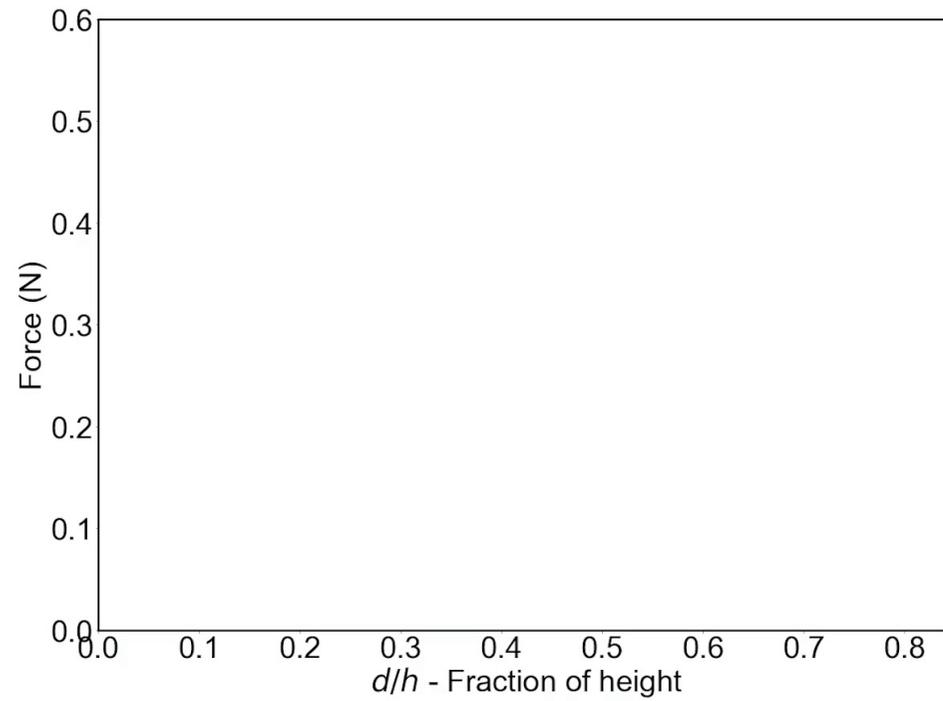
DEPLOYMENT OF A SPHERICAL CAP



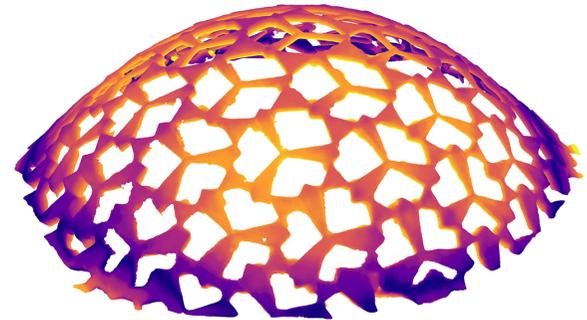
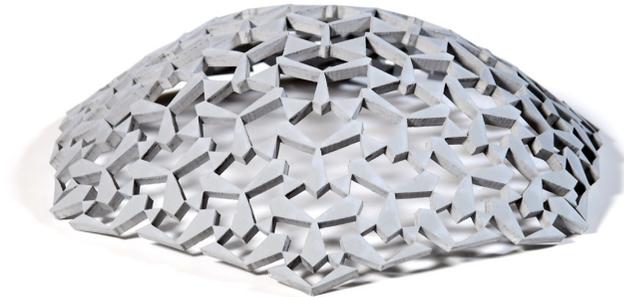
MECHANICAL CHARACTERISTICS



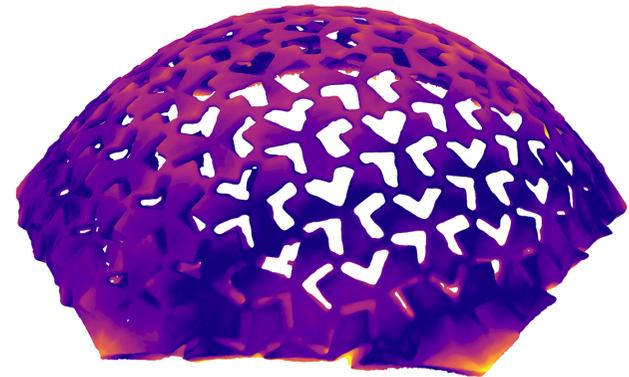
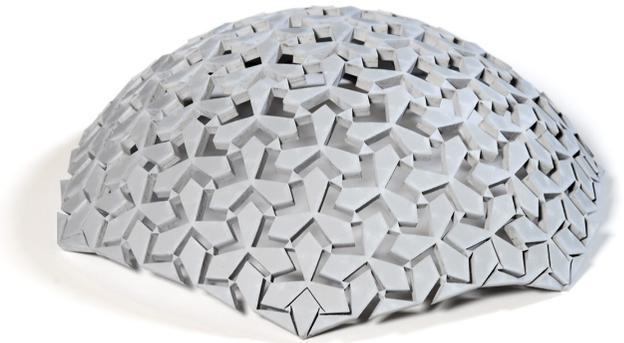
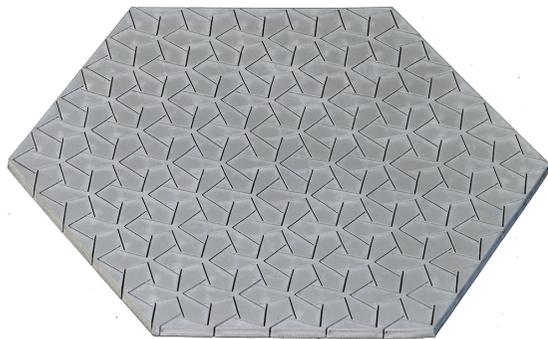
Thanks to fleXLab



SHAPE TRANSFORMATION



0 2.0% l_{diag}



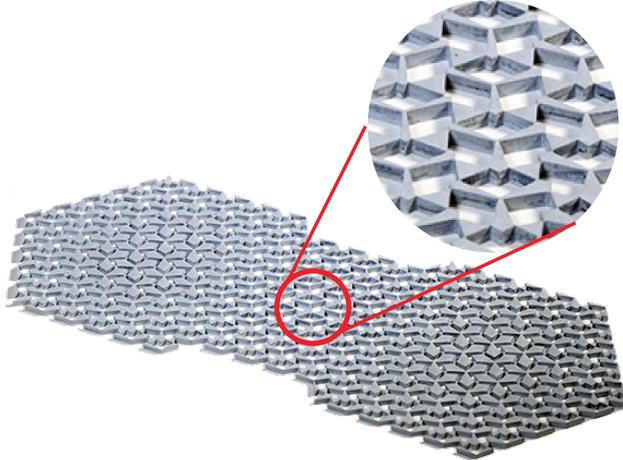
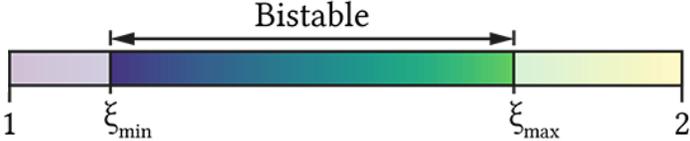
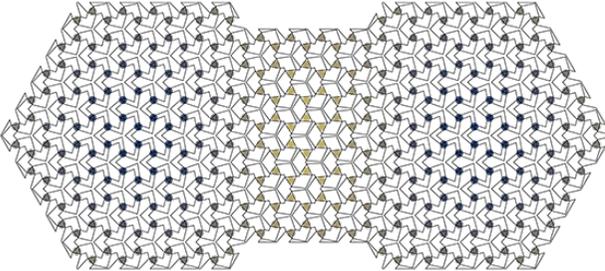
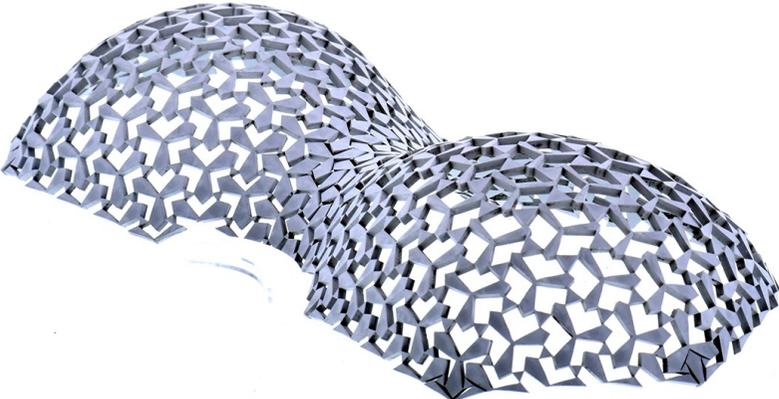
CHANGE OF TOPOLOGY



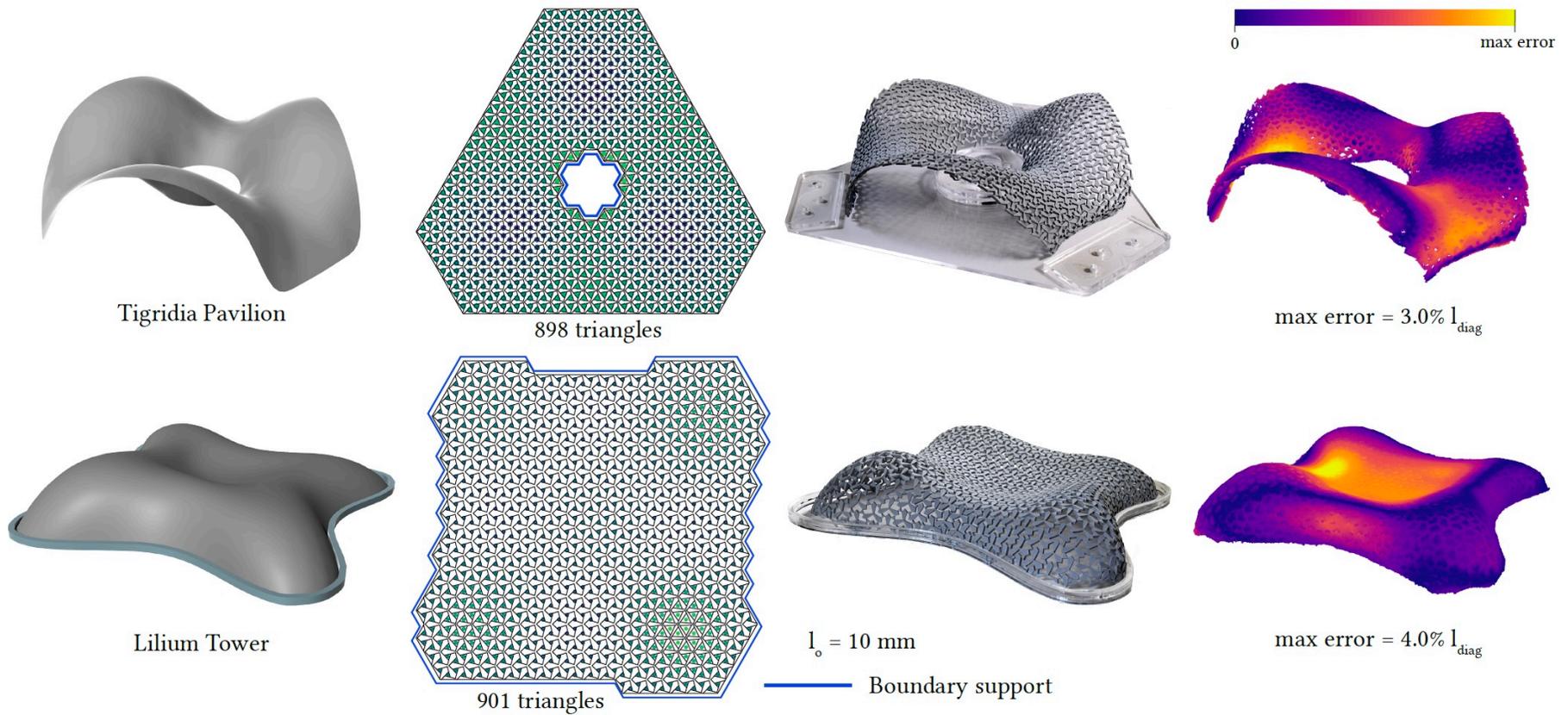
Target surface



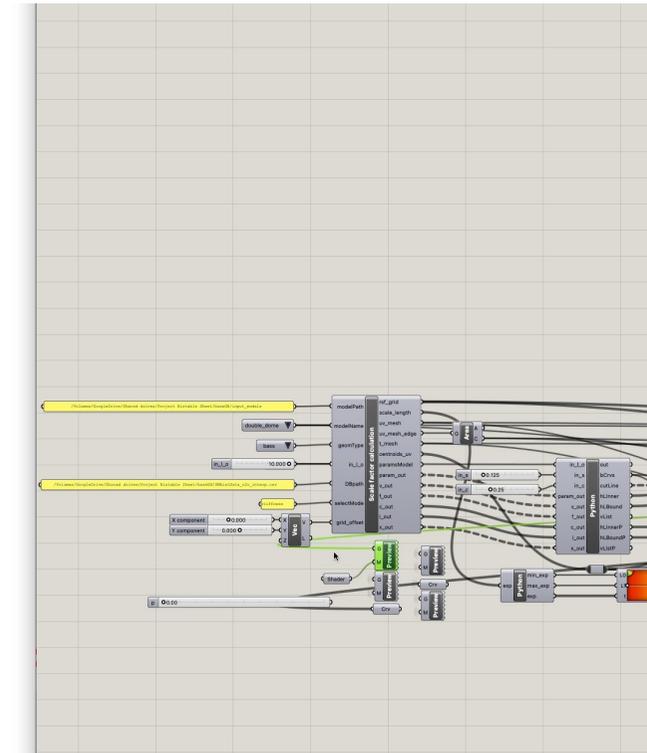
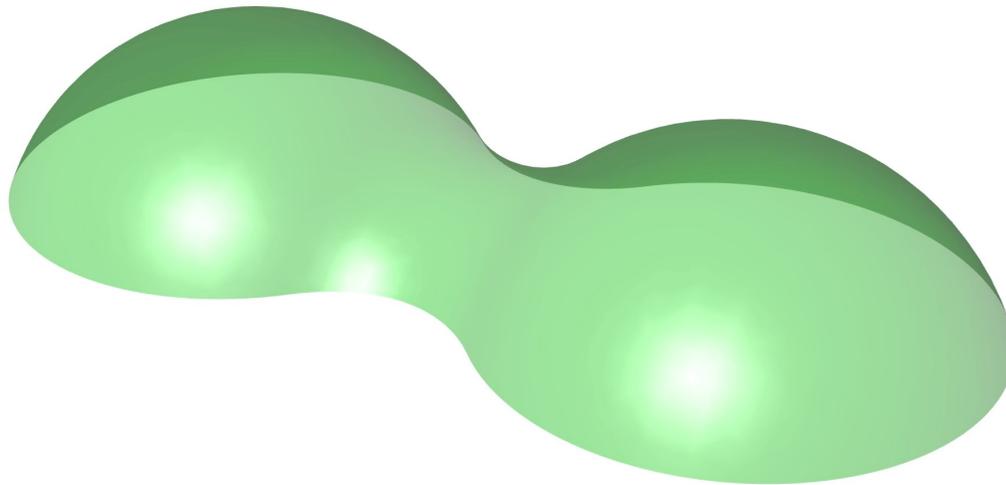
CONTRACTING MICROSTRUCTURE



RESULTS



GRASSHOPPER SCRIPT



<https://go.epfl.ch/bass>

LIMITATIONS AND NEXT STEPS

Range of expansion and contraction

Minimal (not bistable)
Maximal (geometry)

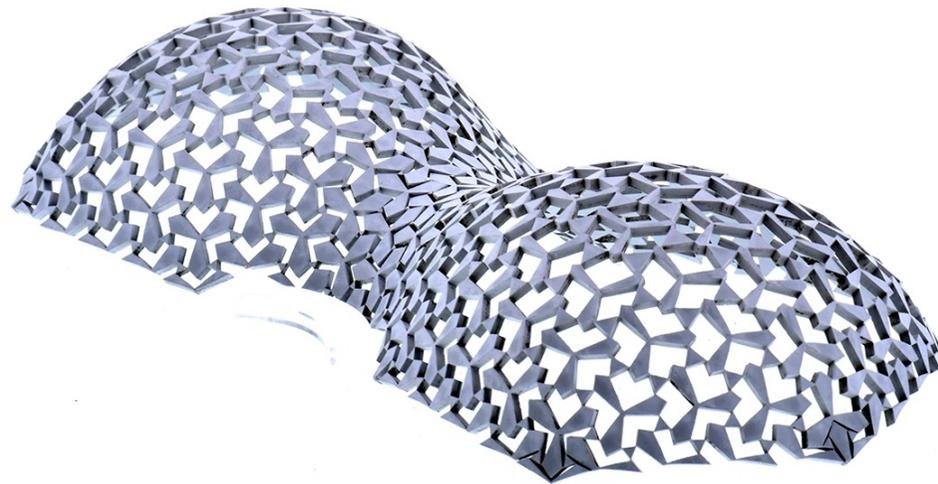
Global size of the surface

Assembly using parts and joints

Tradeoff

Trade off of having flexible material for deployment but stiffness in the deployed state





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