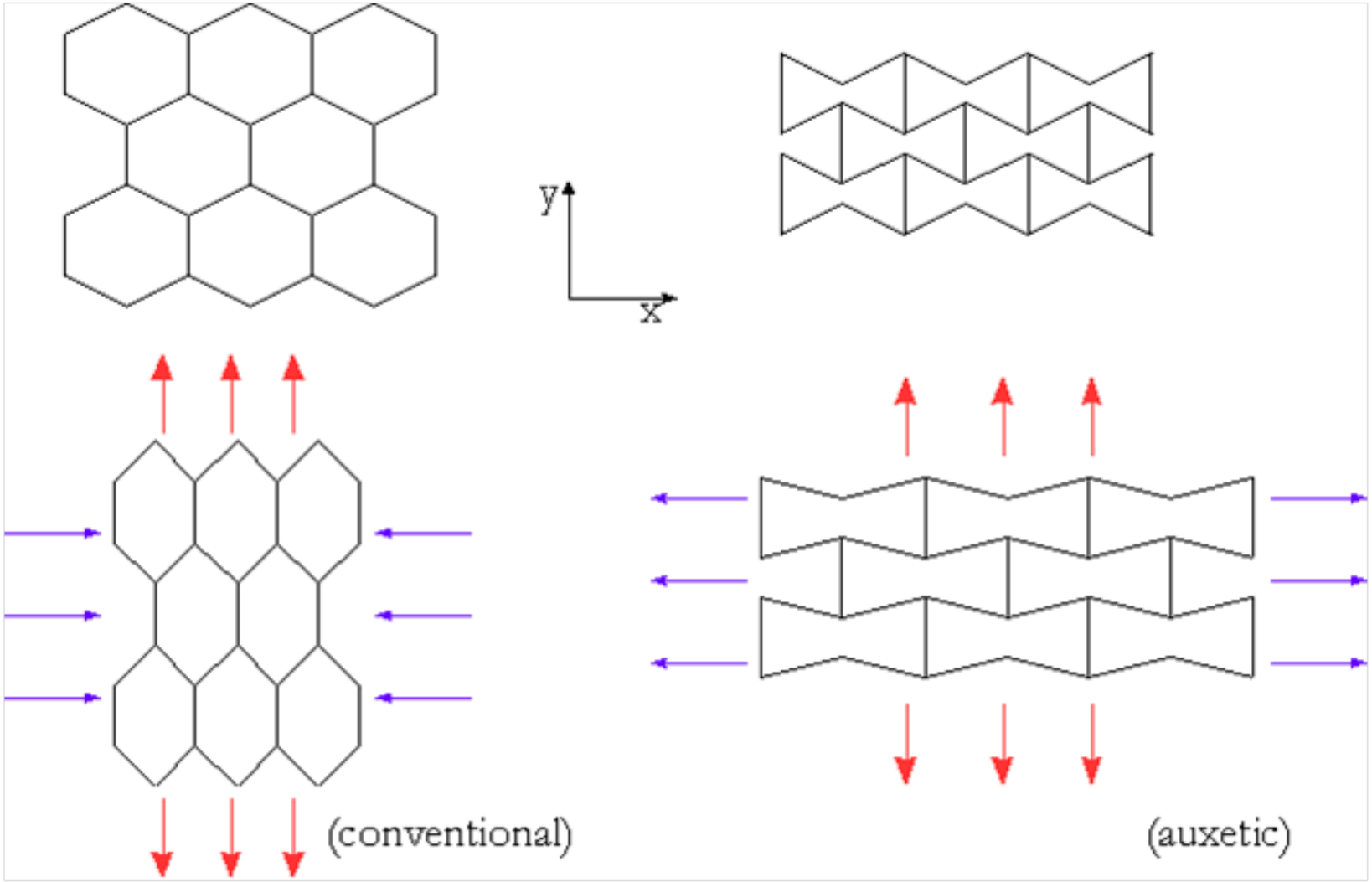
Auxetic mechanisms

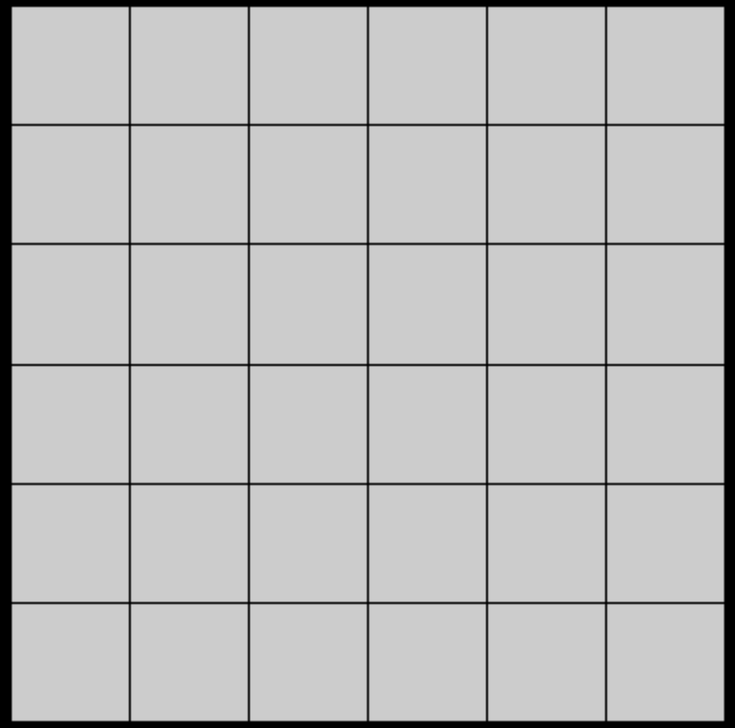
Henry Segerman
Oklahoma State University

Auxetic mechanisms



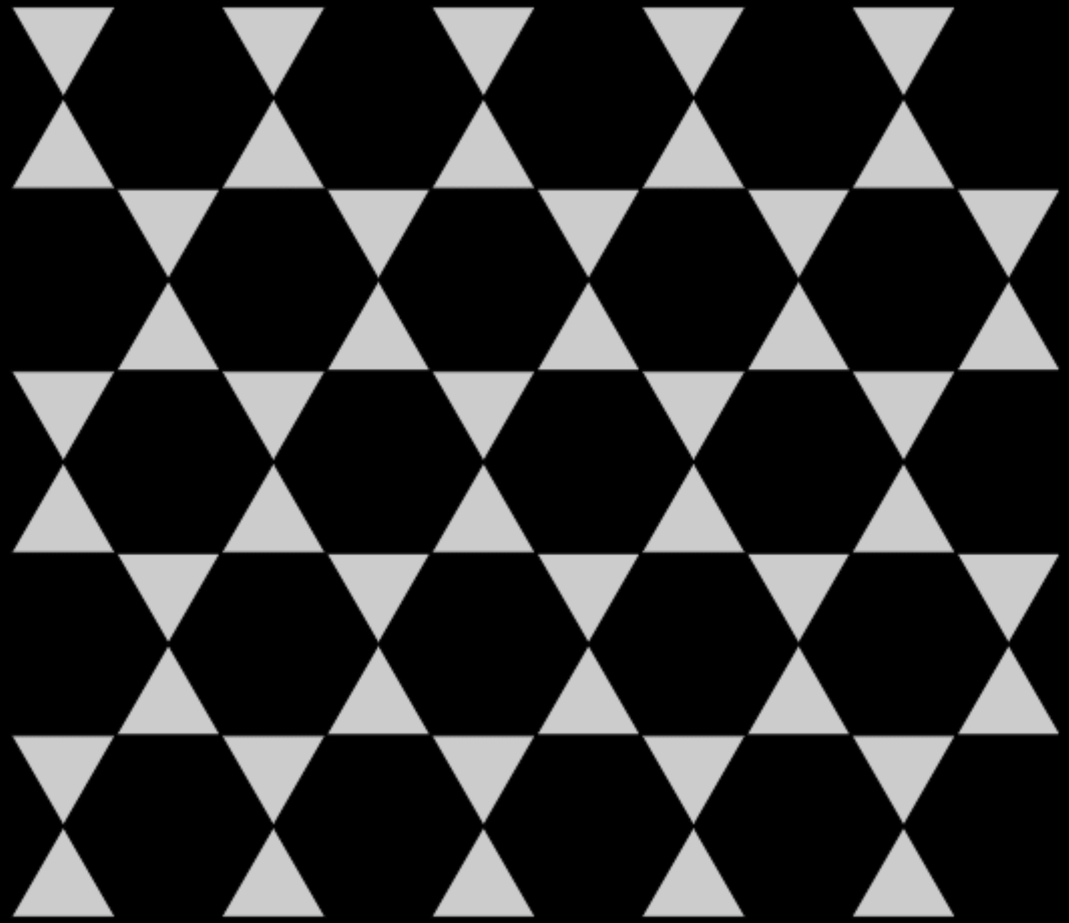
Source: https://smartstructures.wikispaces.com/Auxetic+Materials

Background: 2D auxetic mechanisms



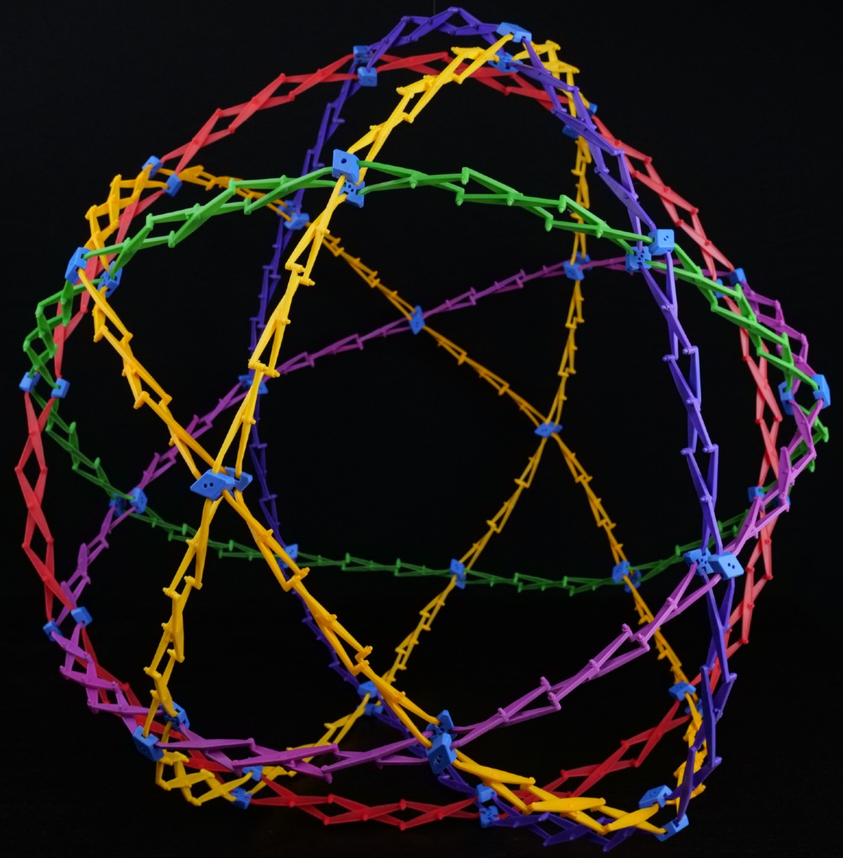
Diamond plate mechanism

Background: 2D auxetic mechanisms

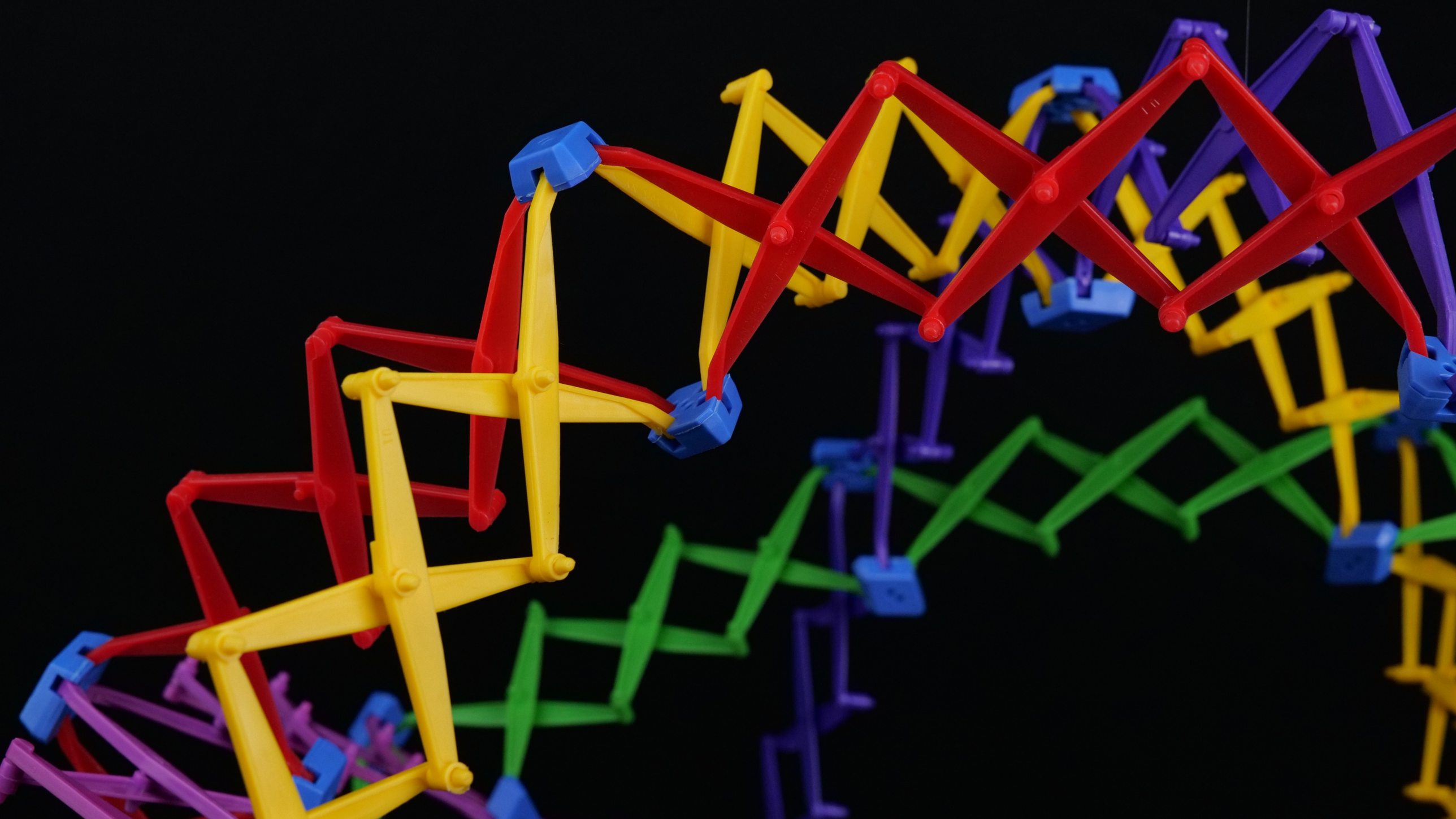


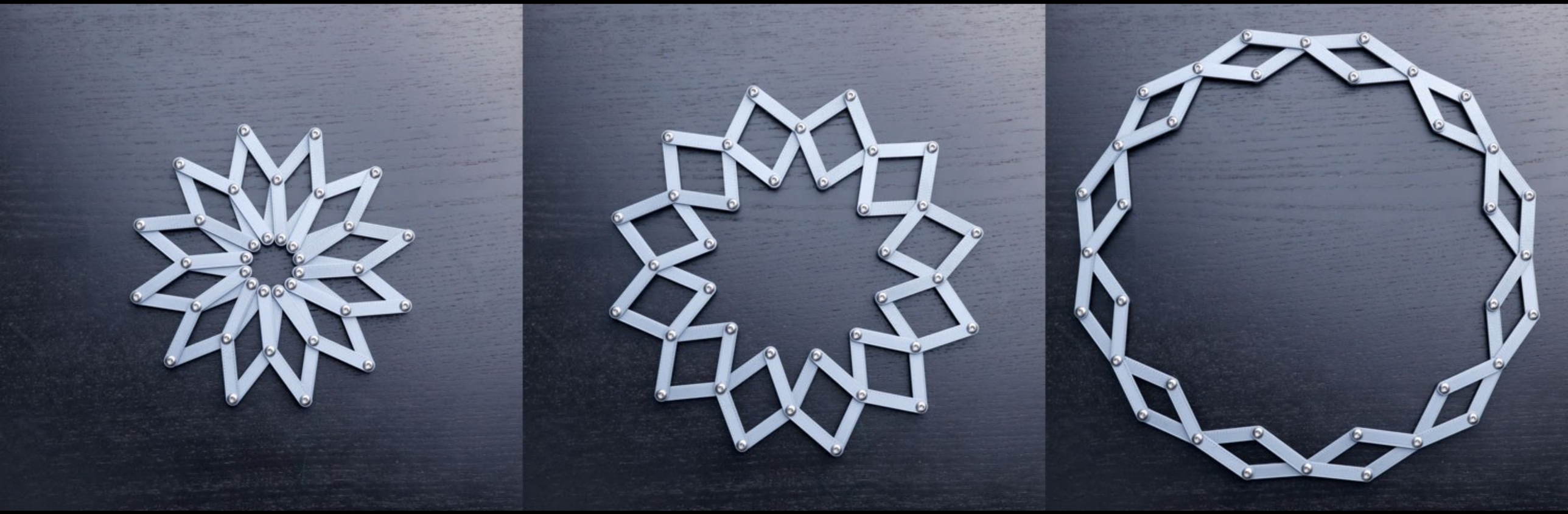
Kagome mechanism

Background: 2D auxetic mechanisms



Hoberman sphere -
the ambient space is 3D, but this is still a surface





Hoberman's polygon mechanism

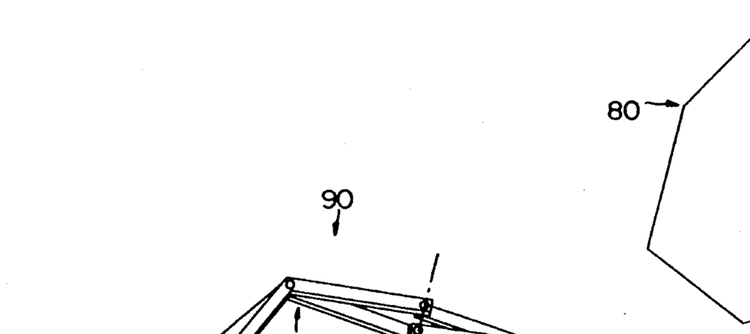


FIG.4

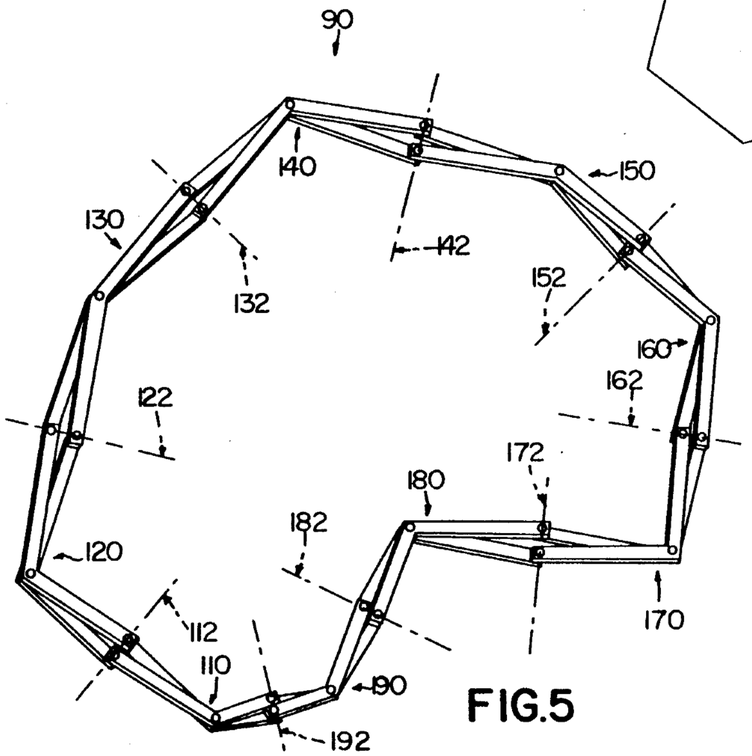


FIG.5

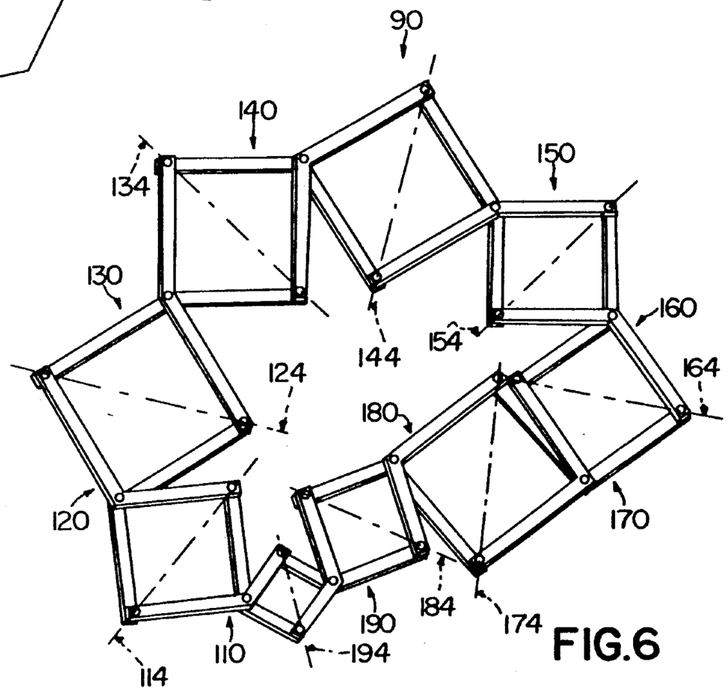
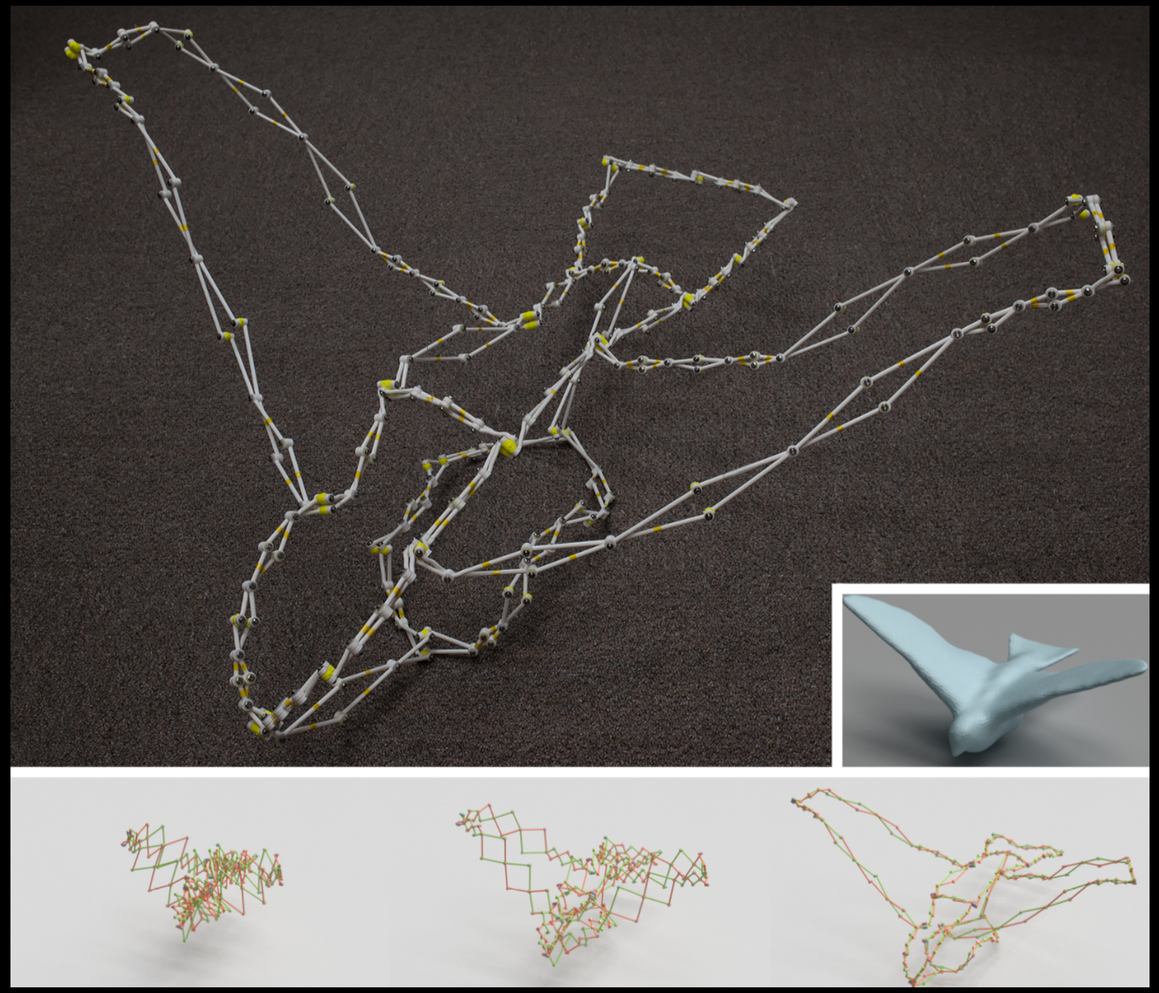


FIG.6

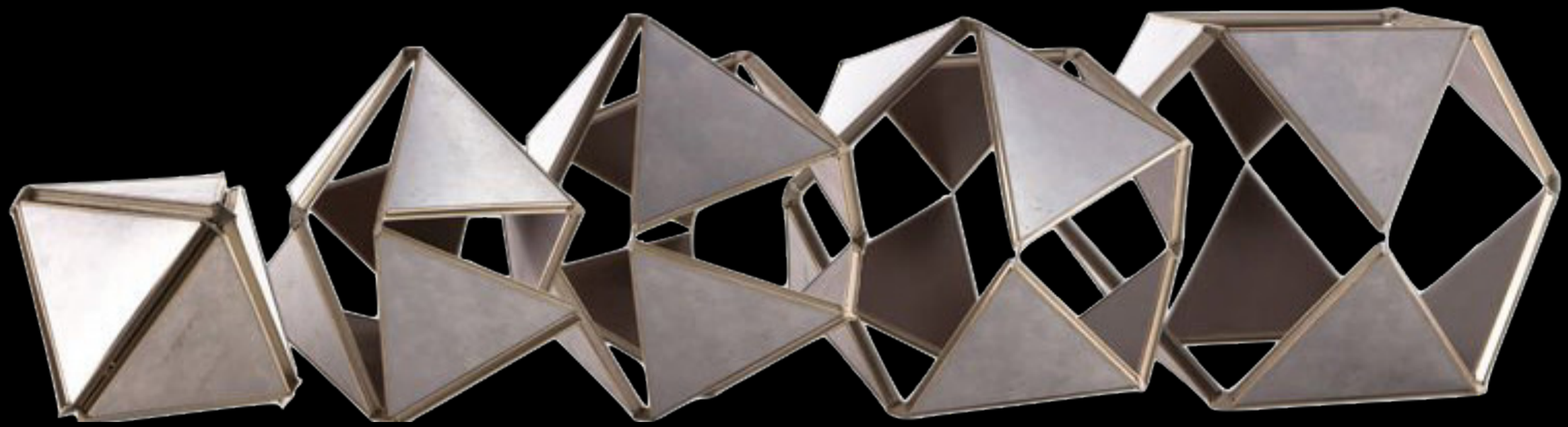
Background: 2D auxetic mechanisms



Source: Zheng, et al. SIGGRAPH 2016

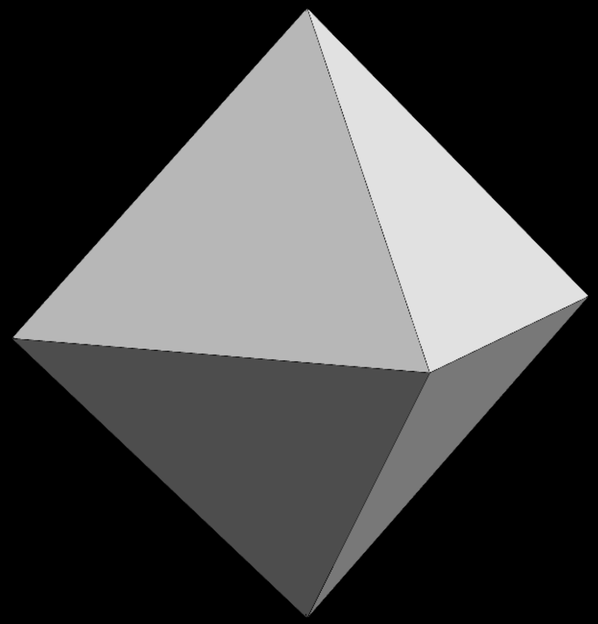
Generalization of Hoberman Sphere to surfaces

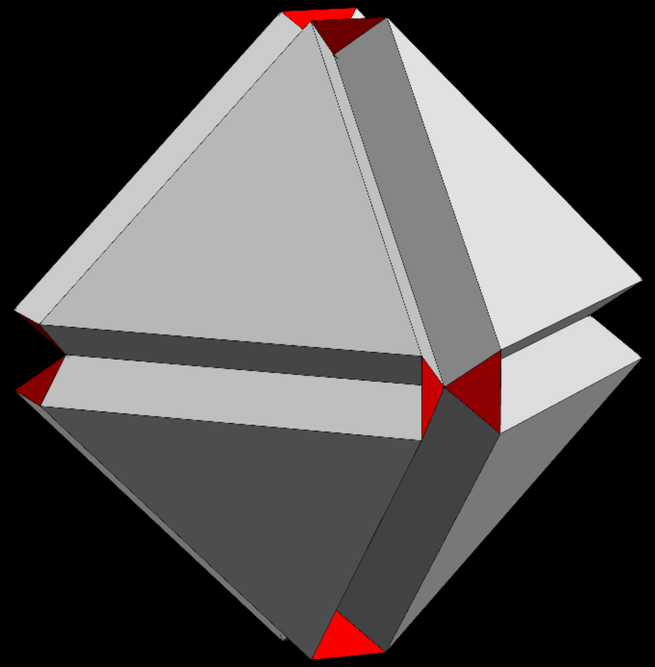
The jitterbug mechanism



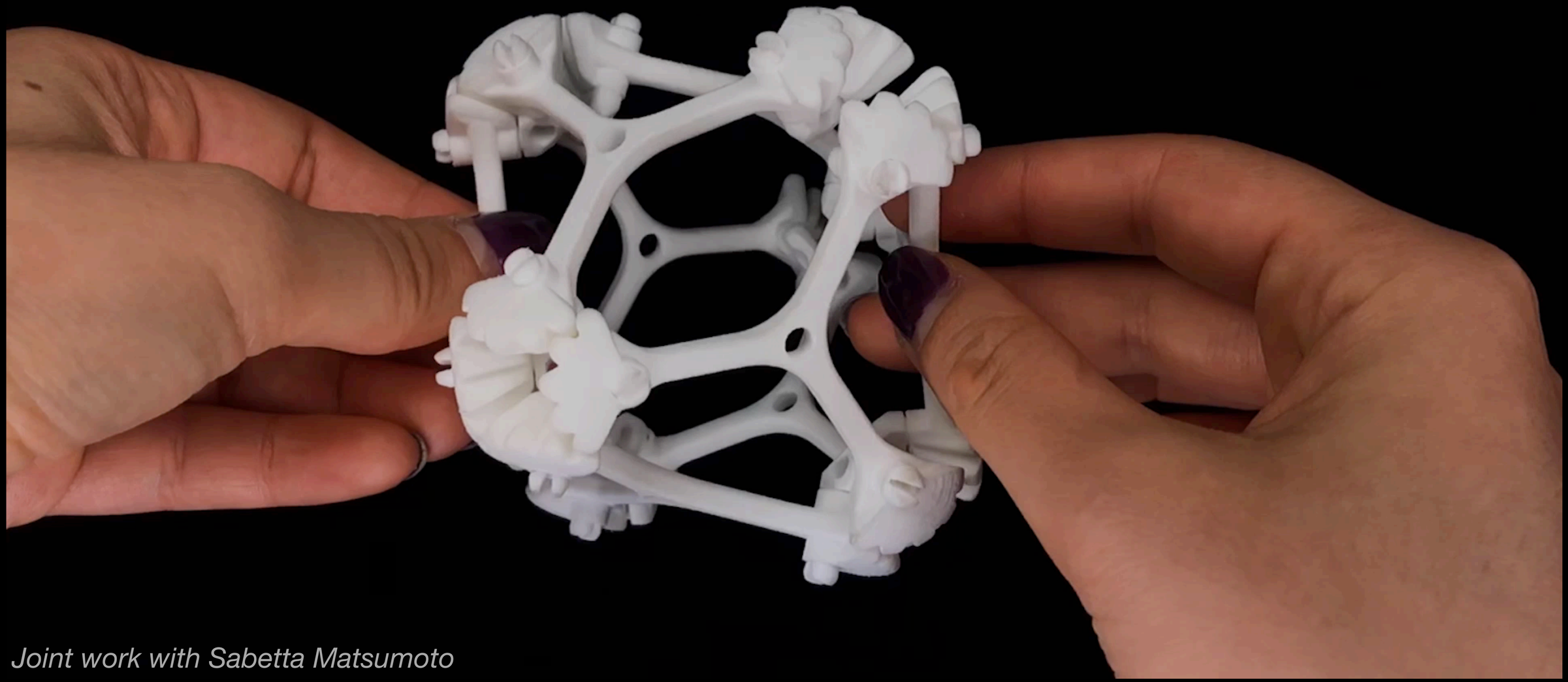
Jitterbug Atom, by Buckminster Fuller

The jitterbug mechanism



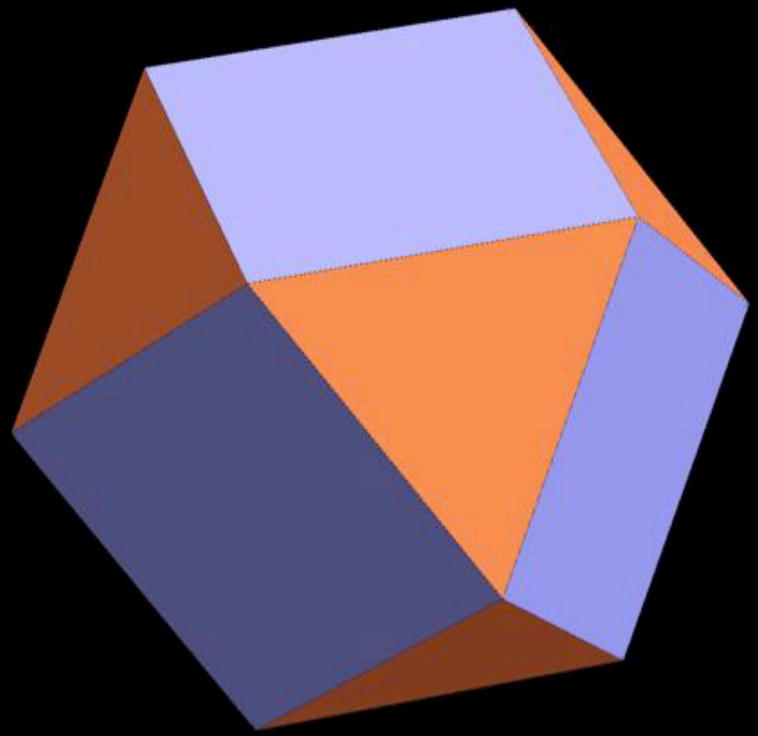


Gearing the jitterbug

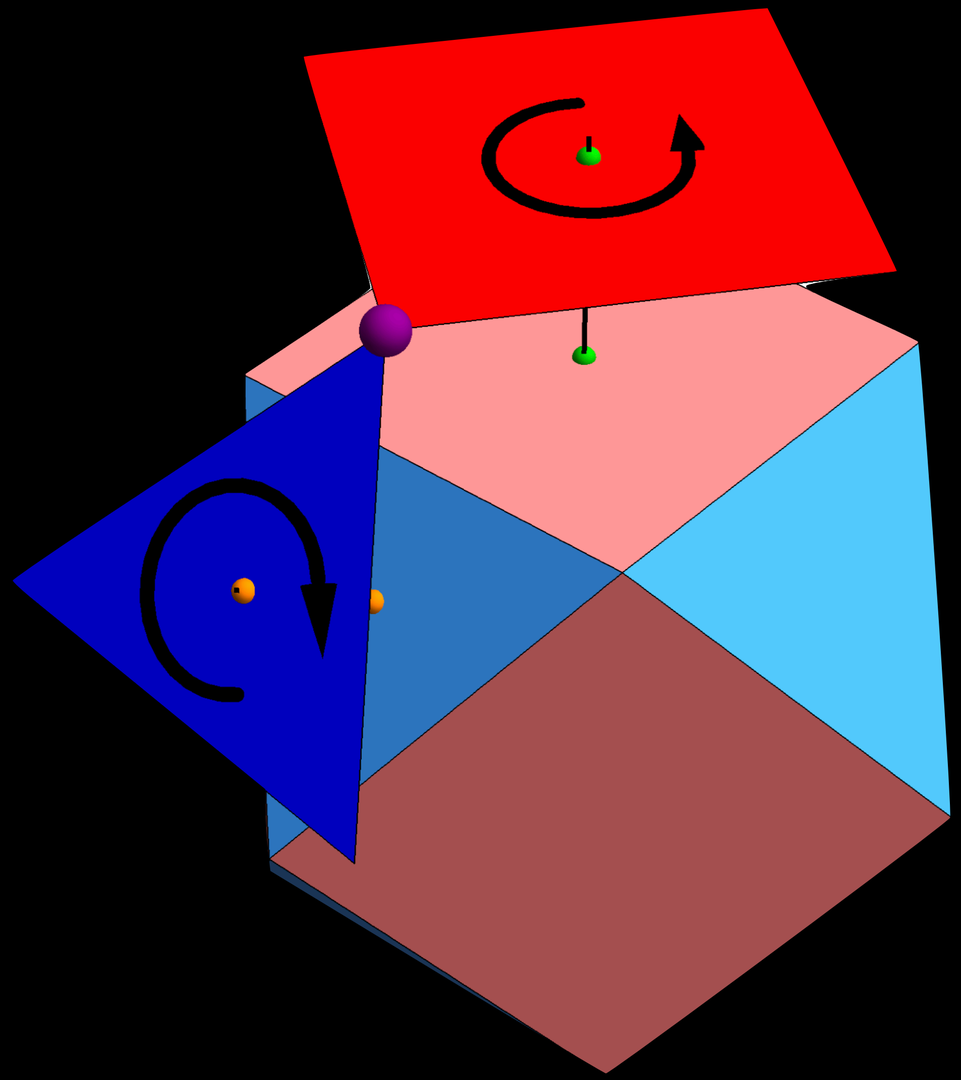


Joint work with Sabetta Matsumoto

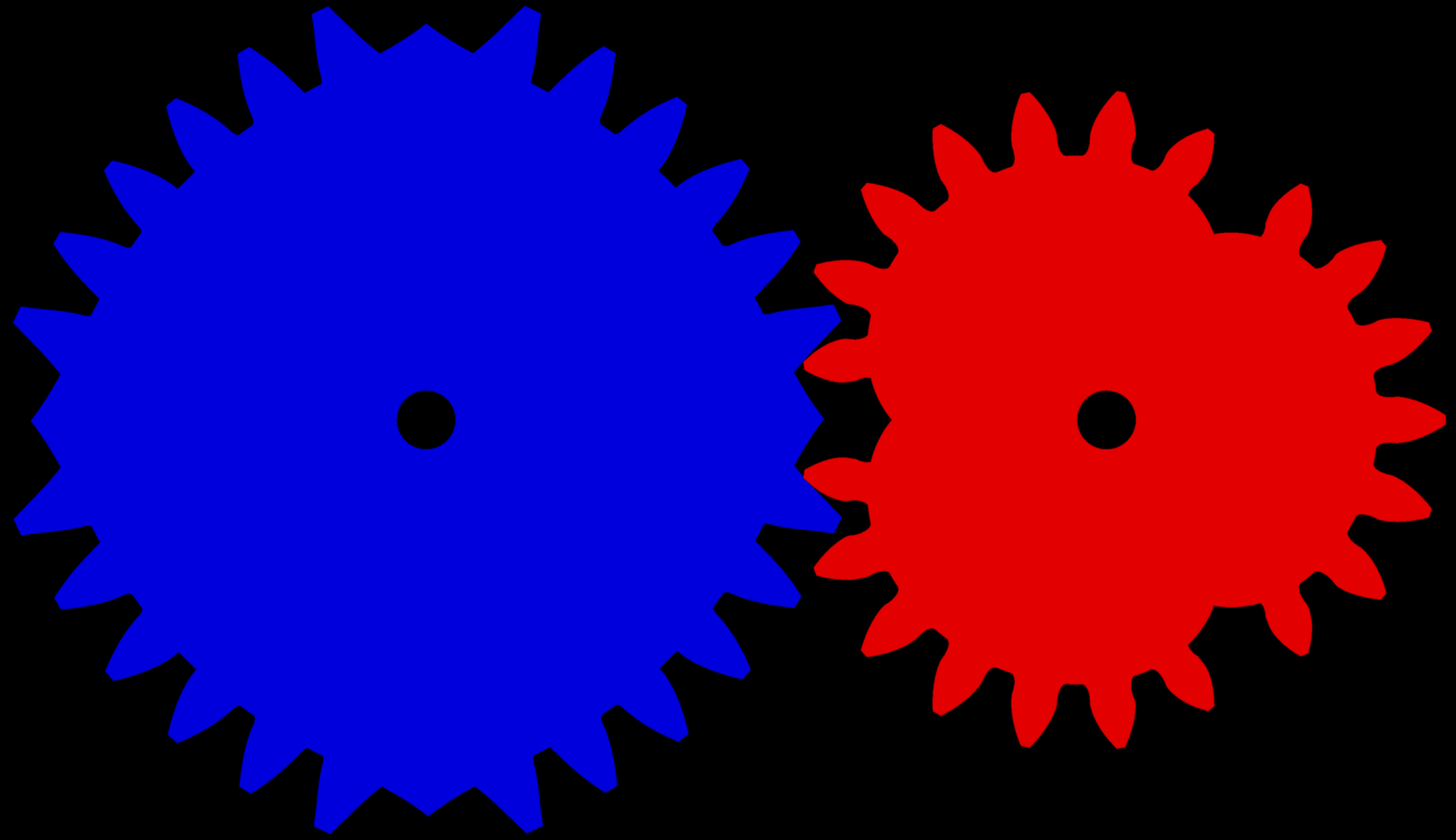
The cuboctahedral jitterbug



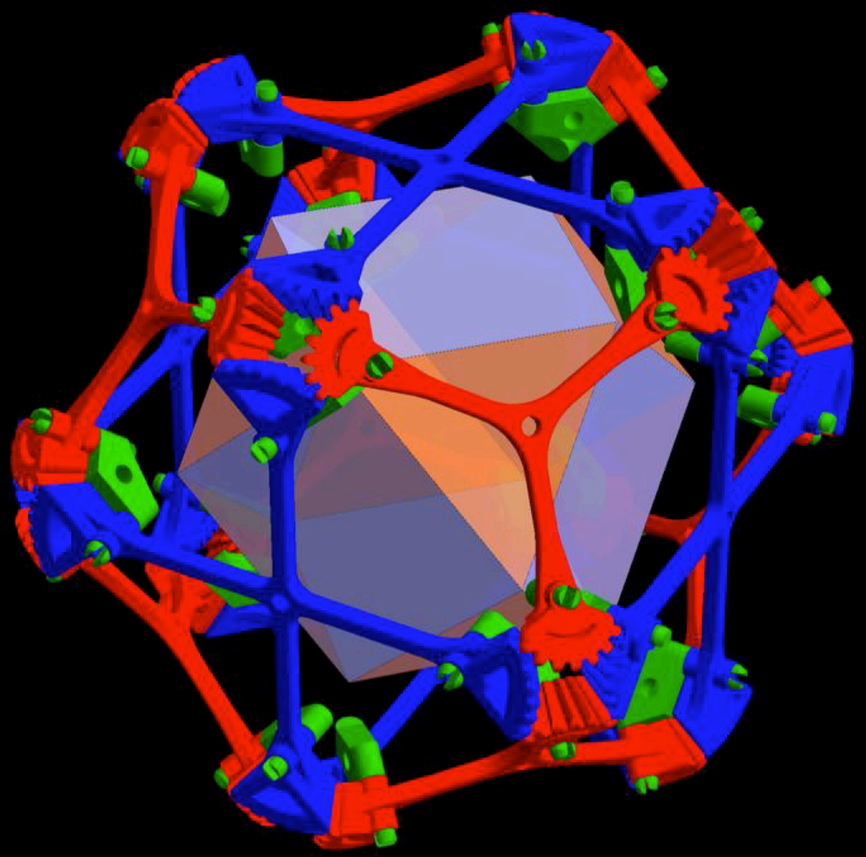
The cuboctahedral jitterbug



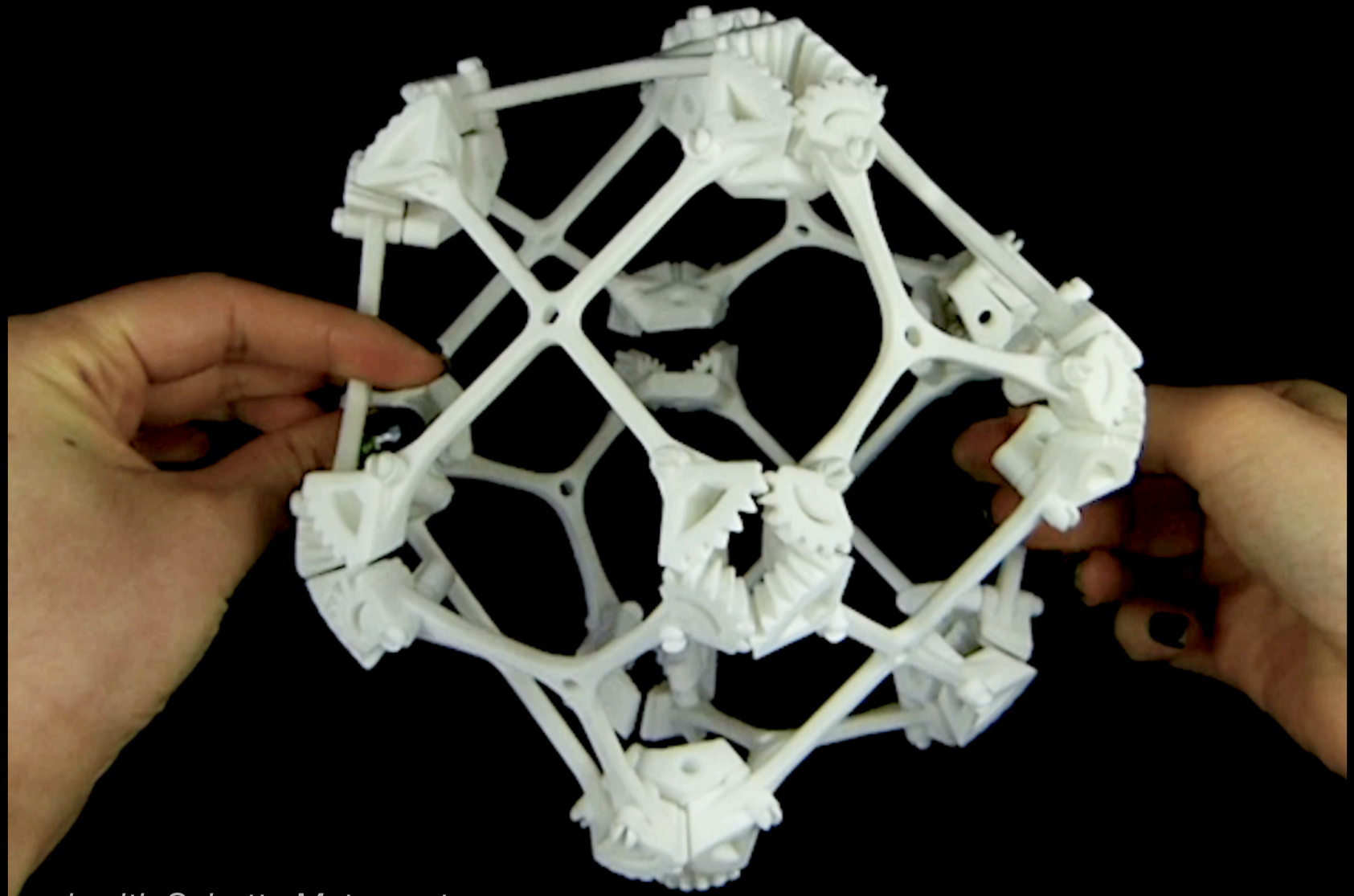
Acircular gears



Geared cuboctahedral jitterbug

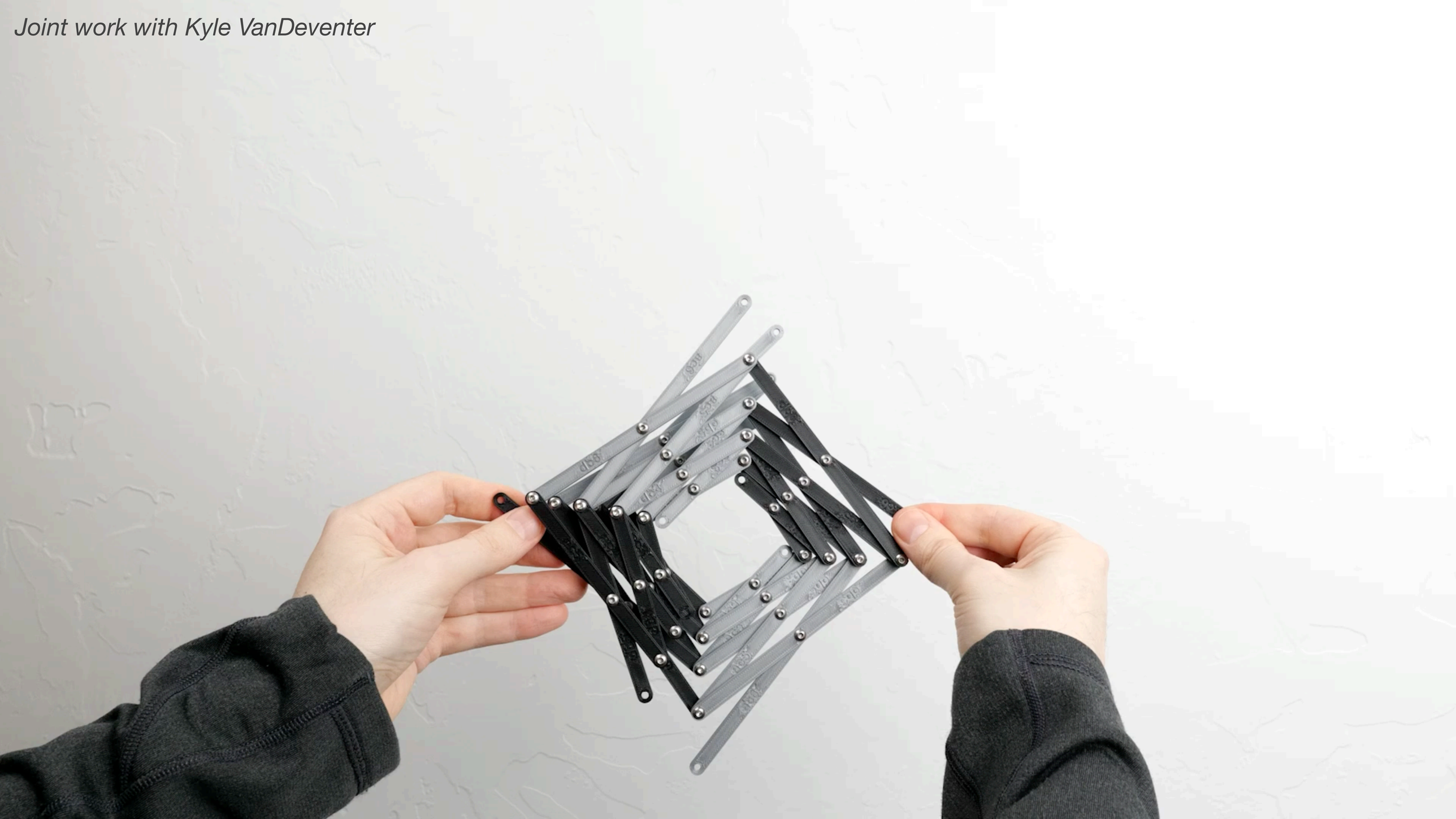


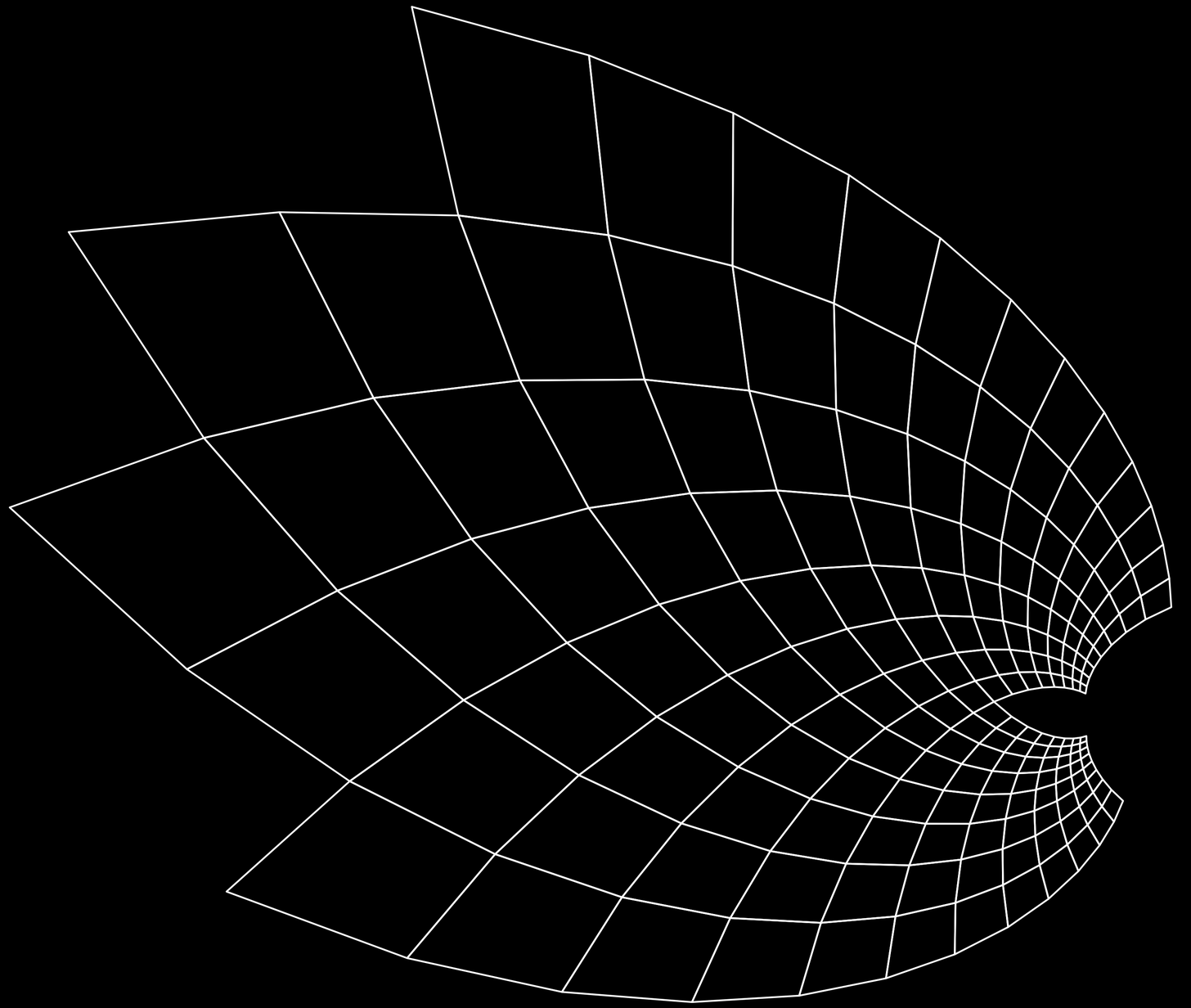
Joint work with Sabetta Matsumoto



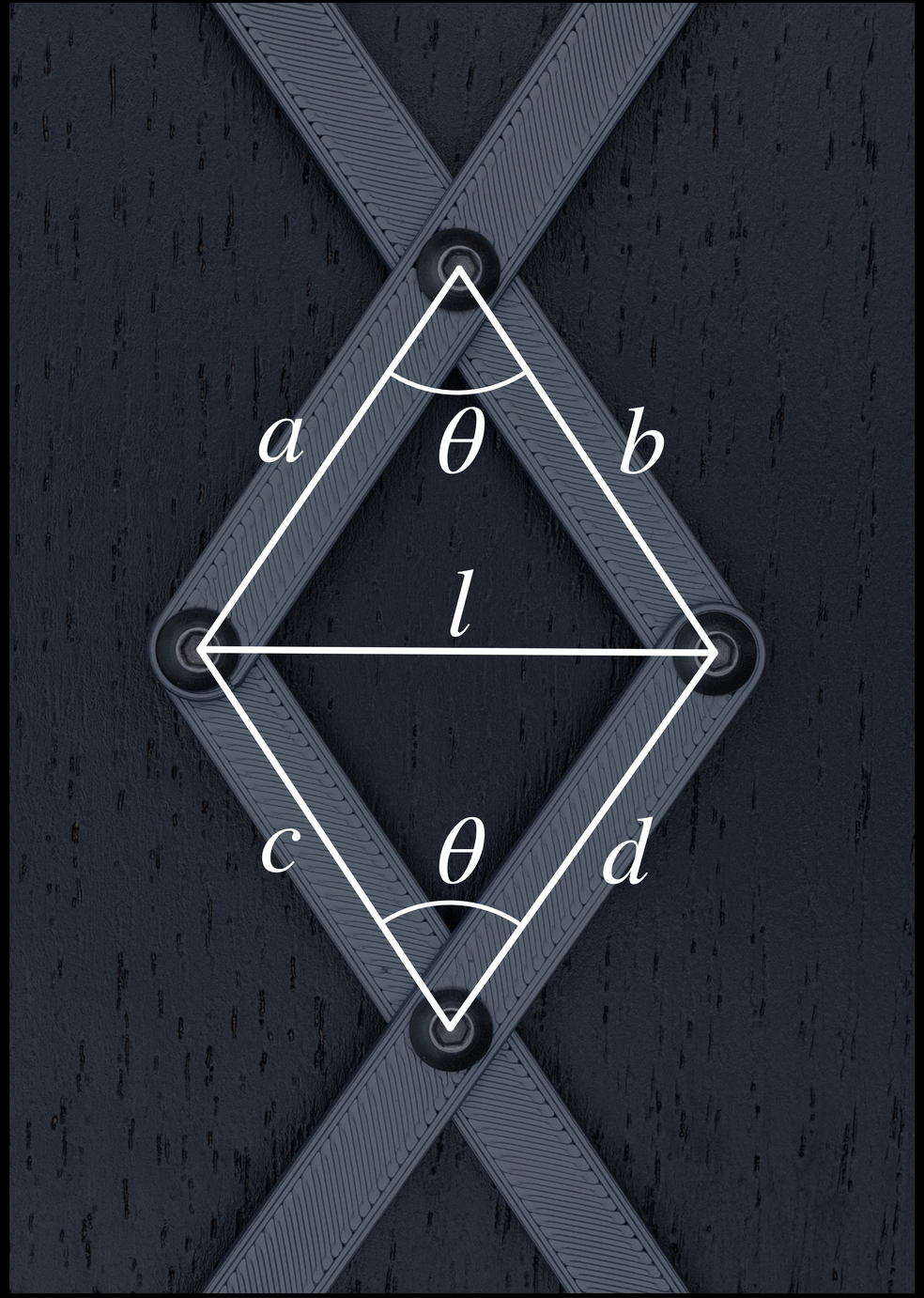
Joint work with Sabetta Matsumoto

Joint work with Kyle VanDeventer





Joint work with Kyle VanDeventer



$$l^2 = a^2 + b^2 - 2ab\cos\theta$$

$$l^2 = c^2 + d^2 - 2cd\cos\theta$$

This is true for all θ so

$$a^2 + b^2 = c^2 + d^2$$

and $$ab = cd$$

These solve to either

$$a = d, b = c$$

(parallelogram)

or $$a = c, b = d$$

(kite)

Joint work with Kyle VanDeventer

Joint work with Kyle VanDeventer

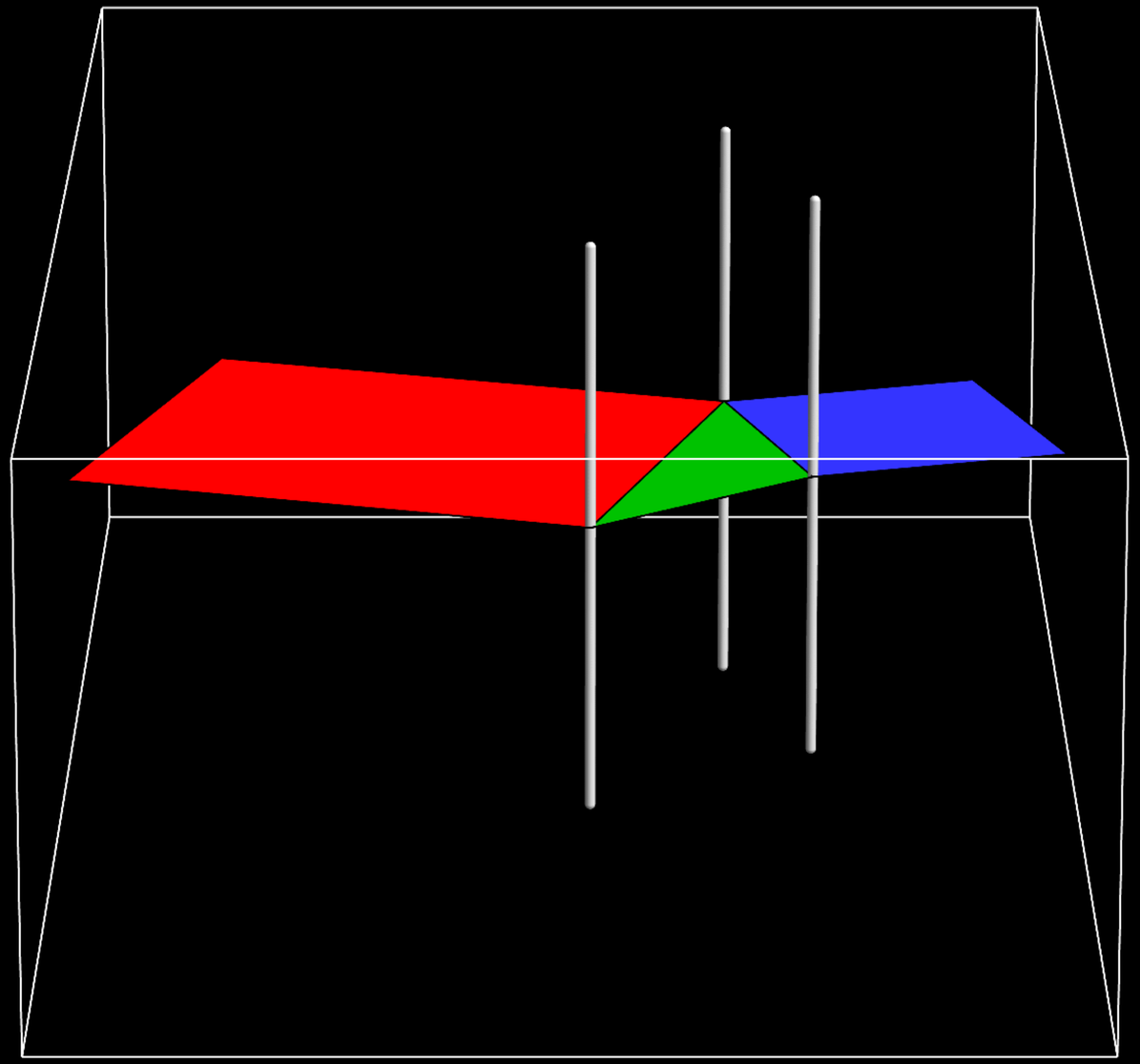
Joint work with Kyle VanDeventer

3D auxetic mechanisms

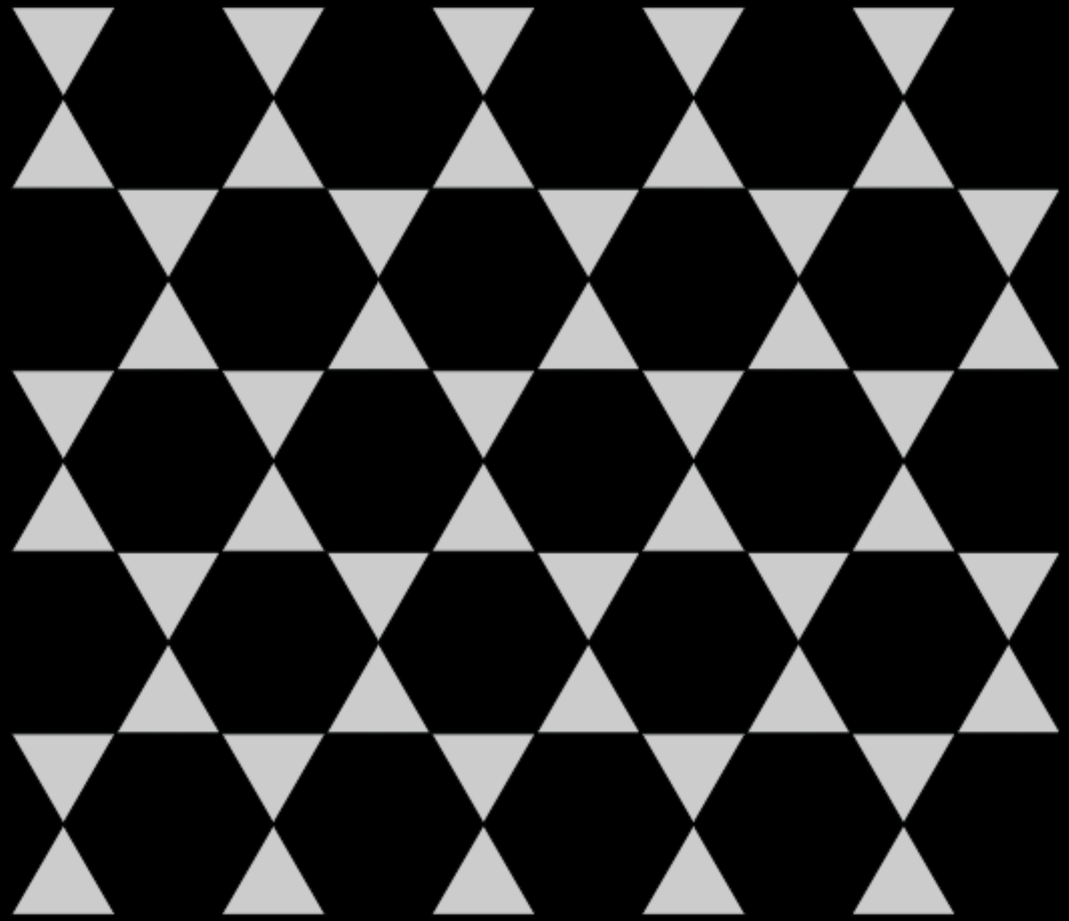
From 2D to 3D

1. Use of the Sarrus linkage
2. Counterrotating elements
3. Branched scissor linkage
4. Auxetic NbO lattice

1. Sarrus linkage

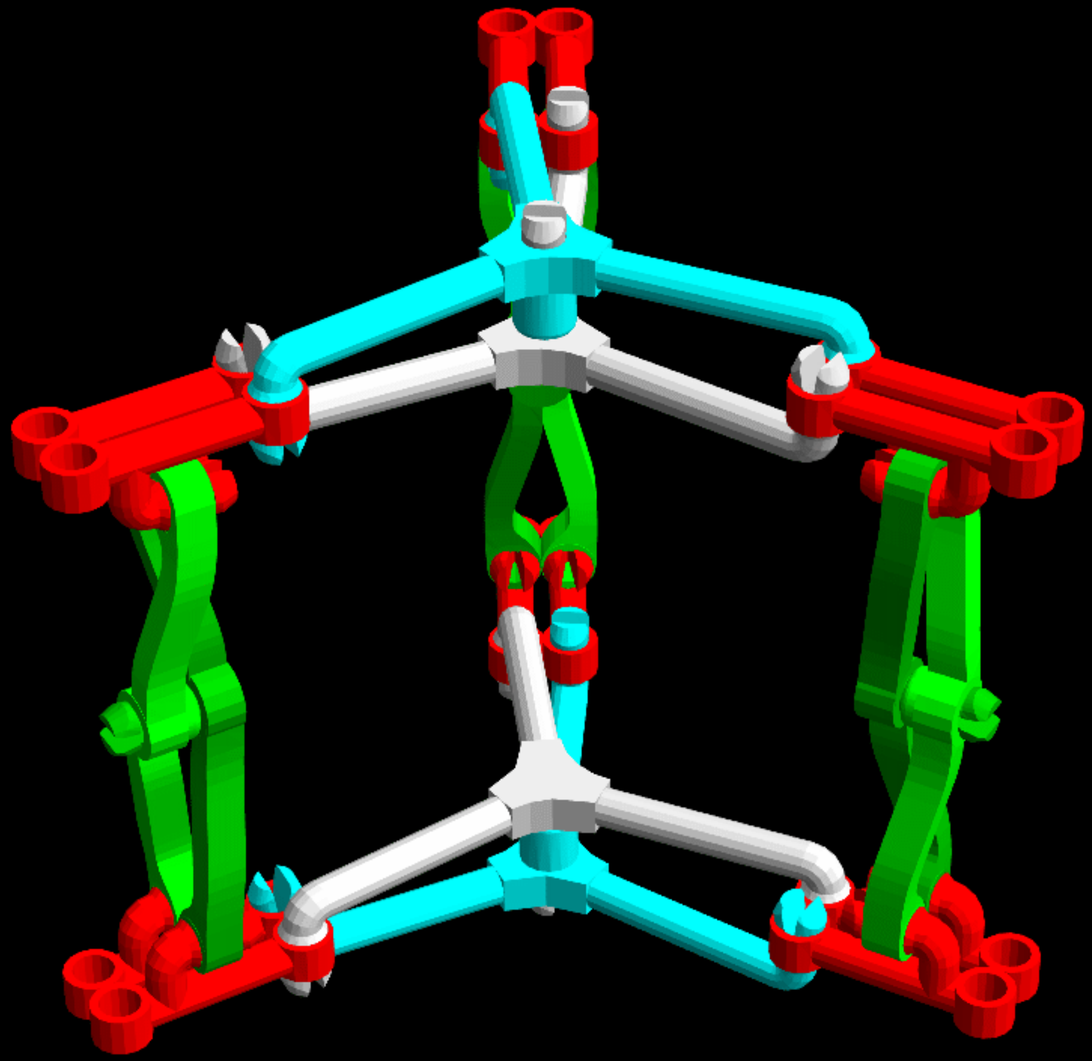


2. Counterrotating kagome

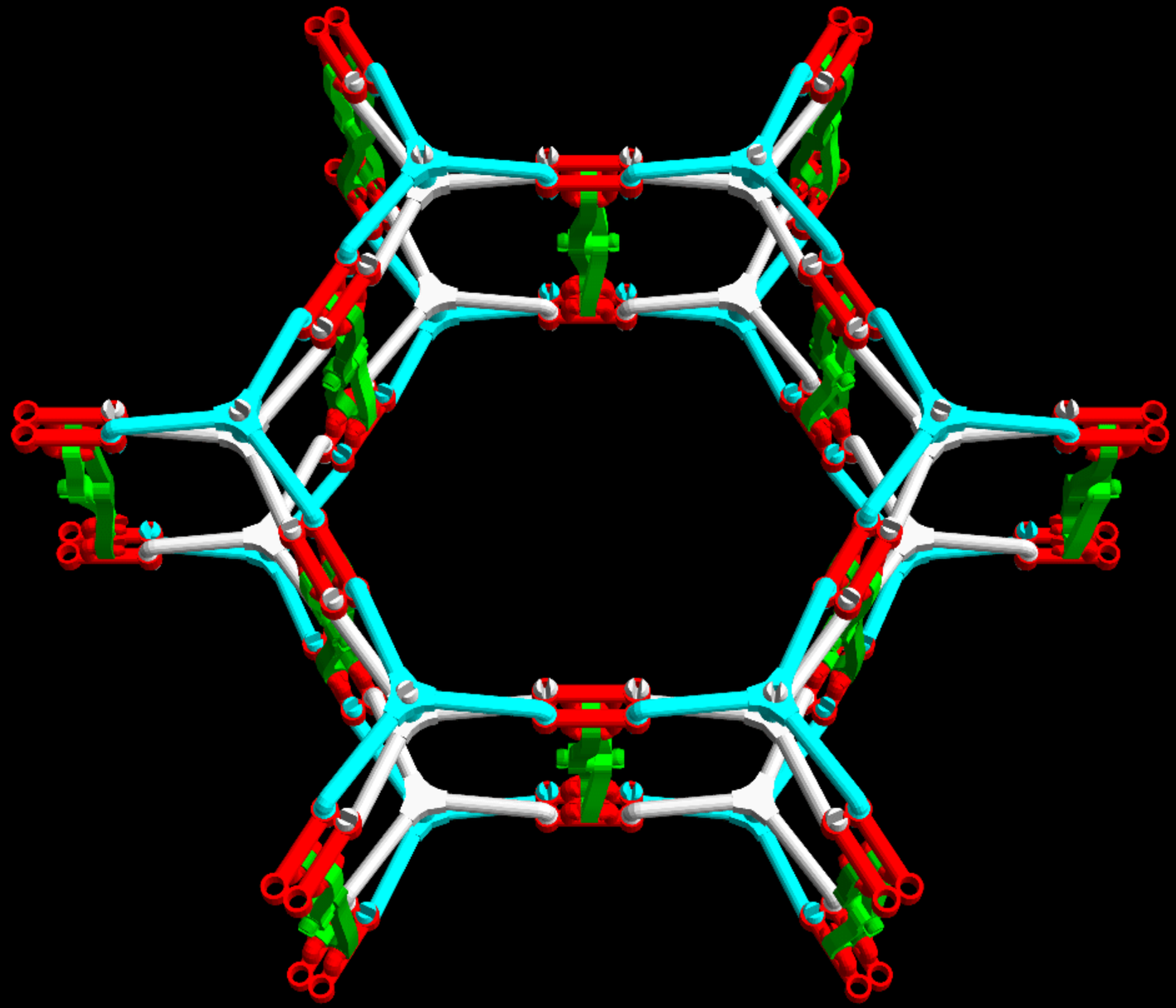


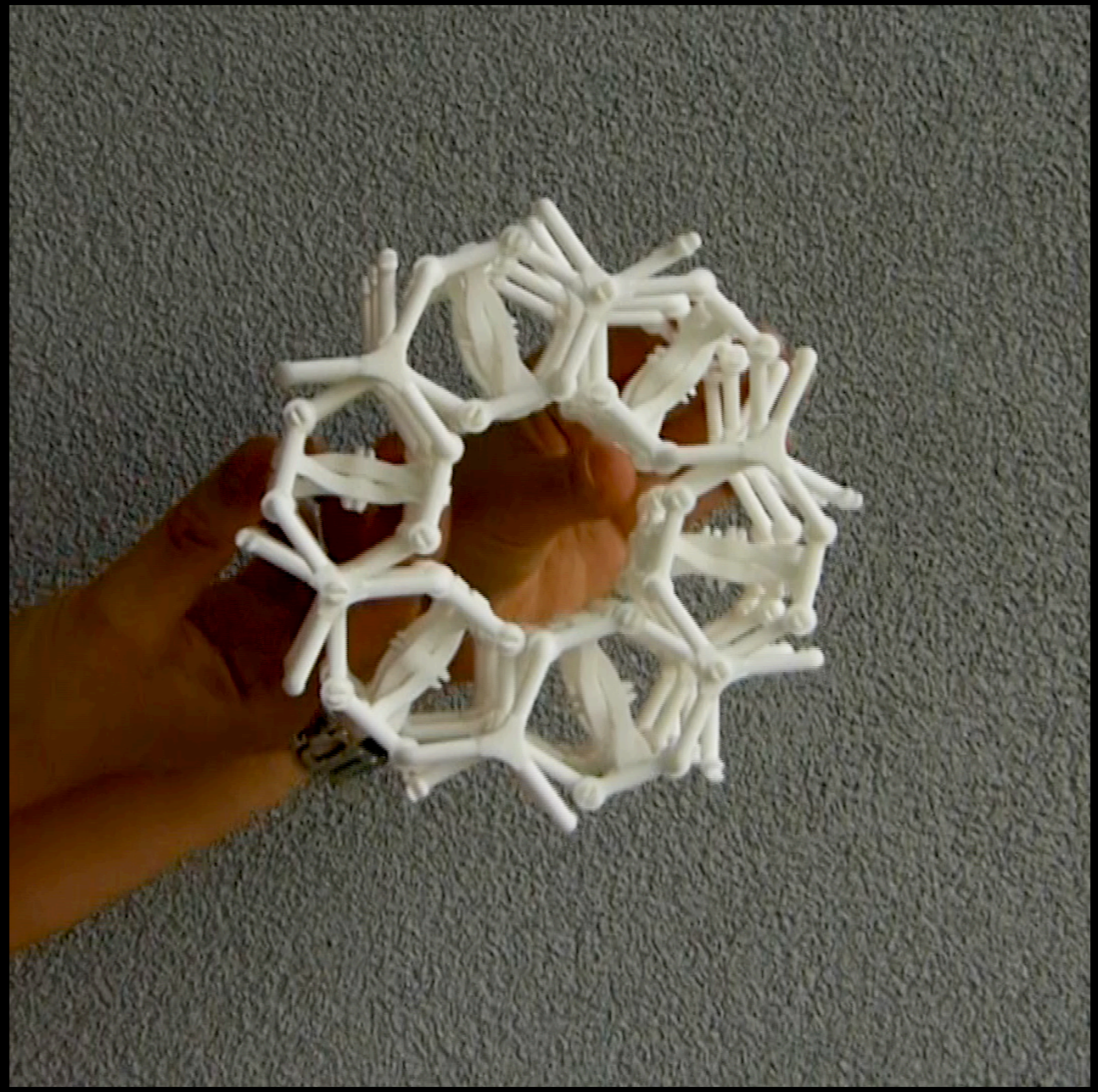
Joint work with Sabetta Matsumoto

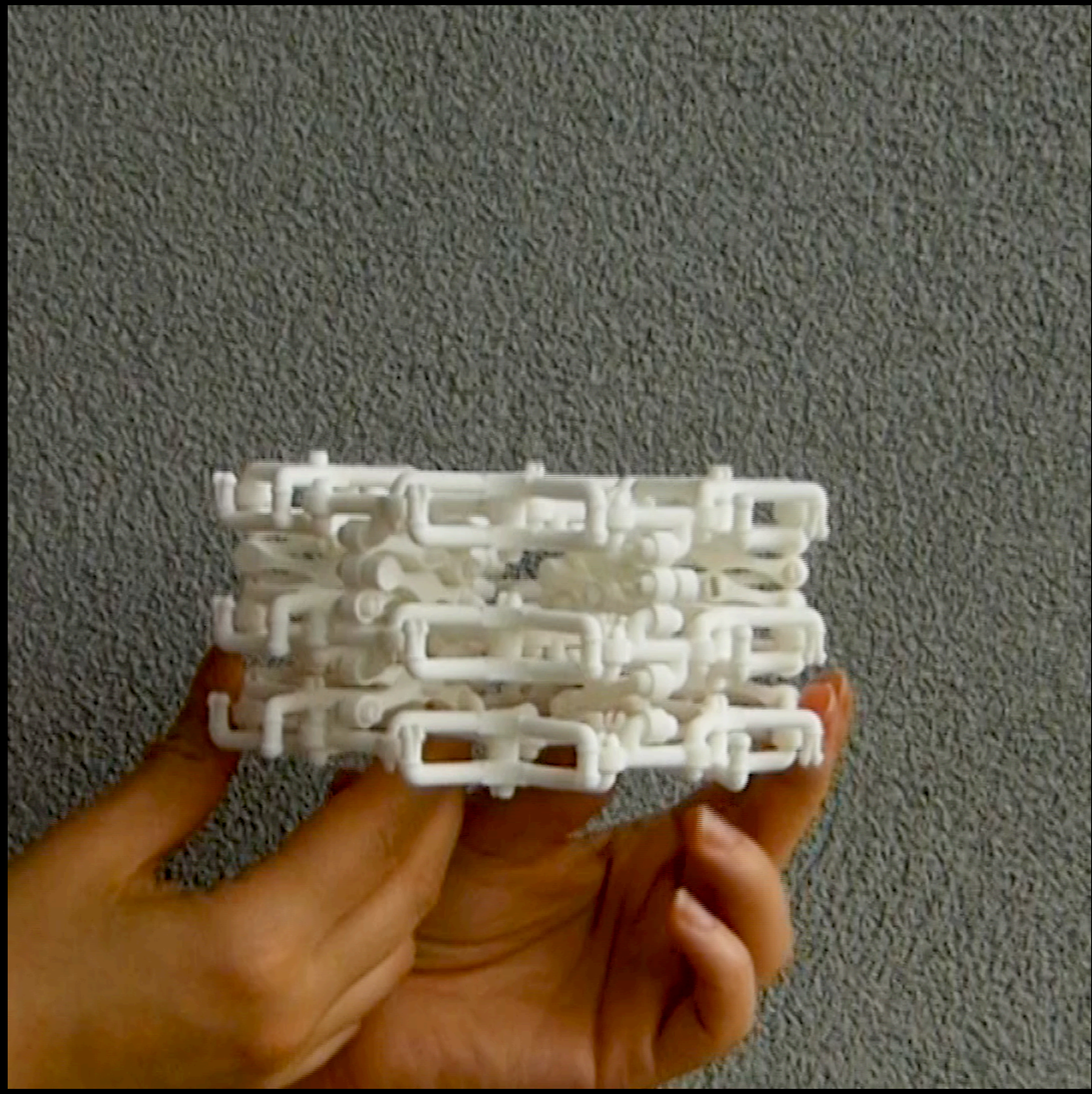
Layered kagome



Layered kagome

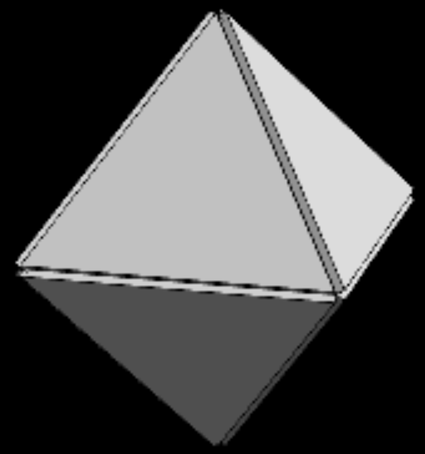




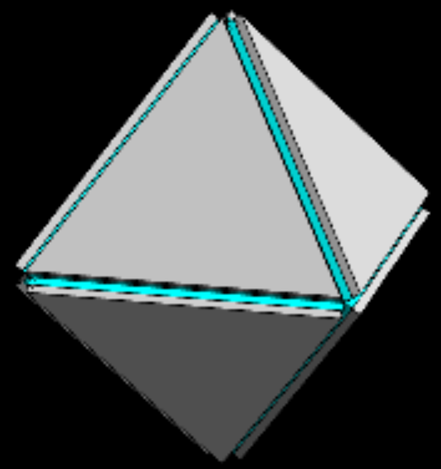


Joint work with Sabetta Matsumoto

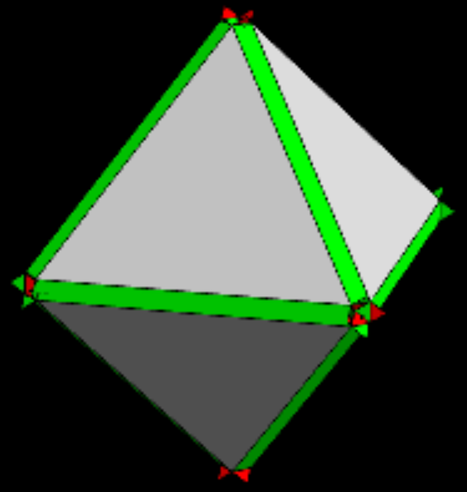
Counterrotating jitterbug



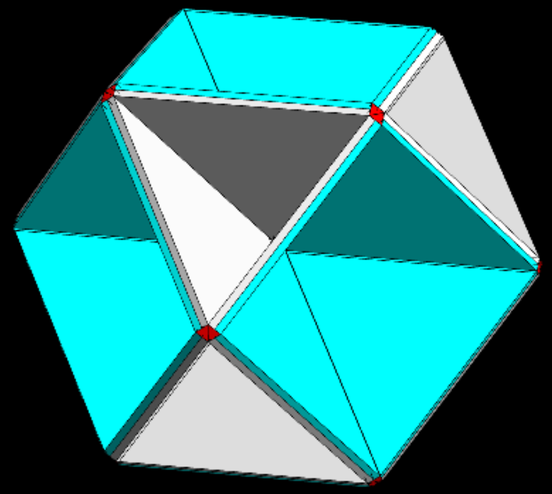
Counterrotating jitterbug

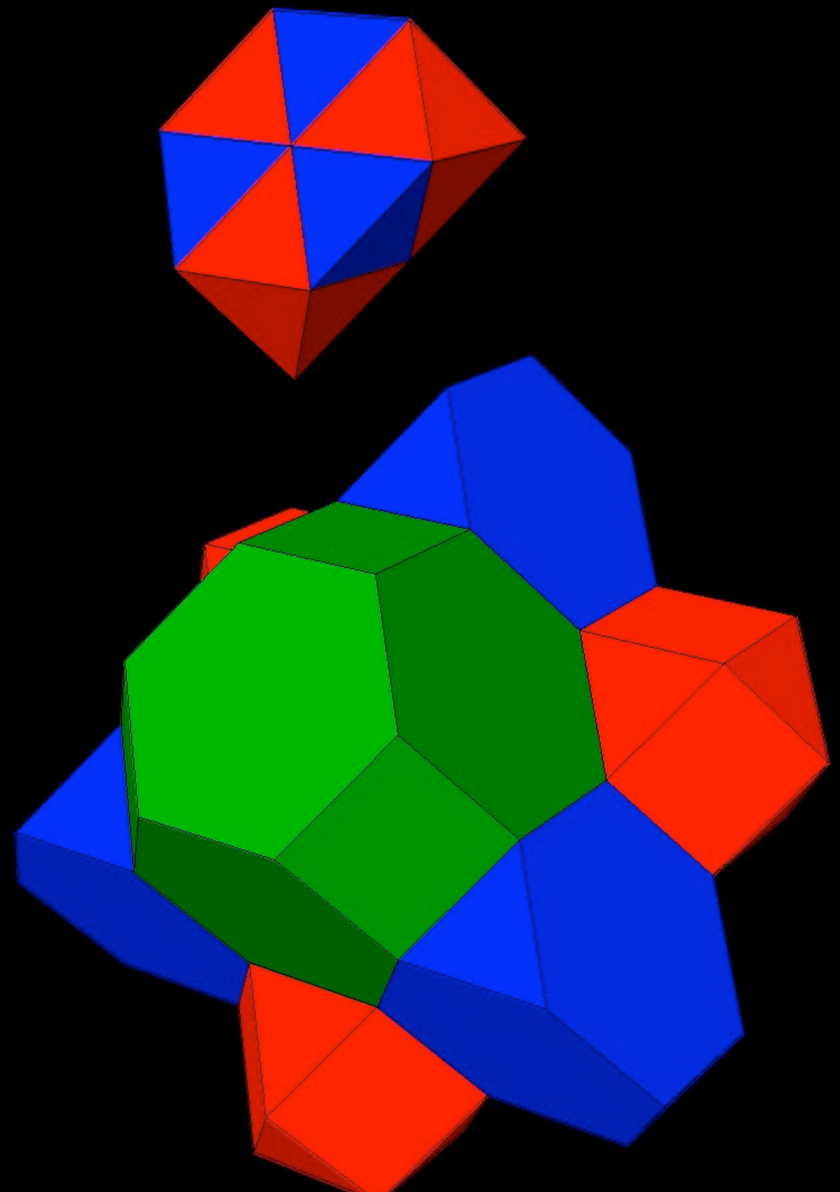


Counterrotating jitterbug

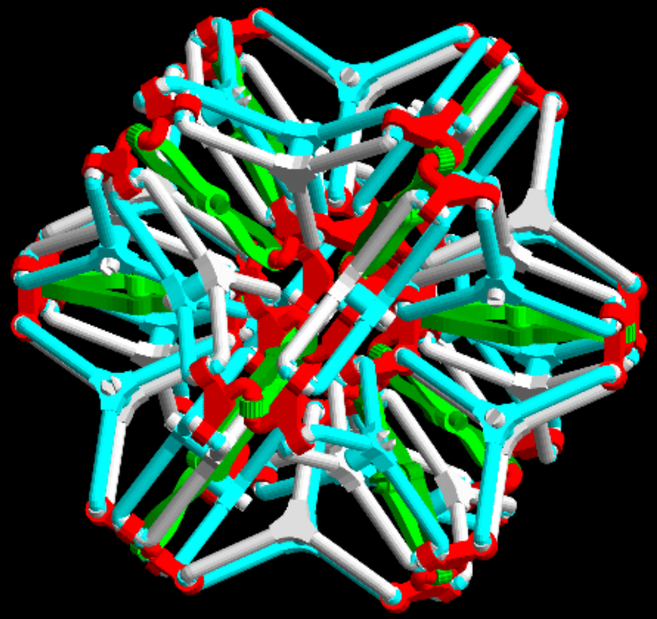


Octet/tatoh auxetic mechanism

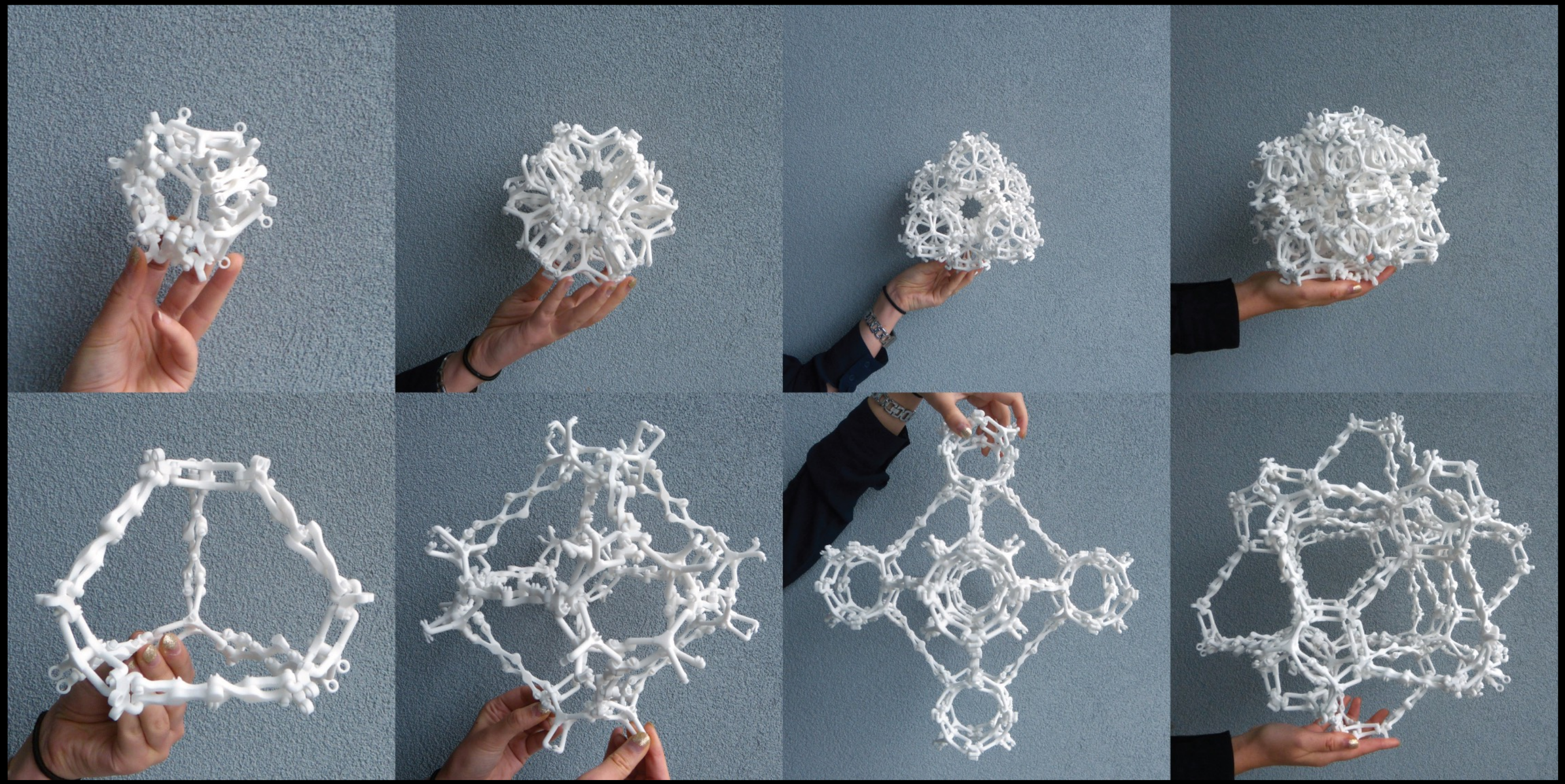




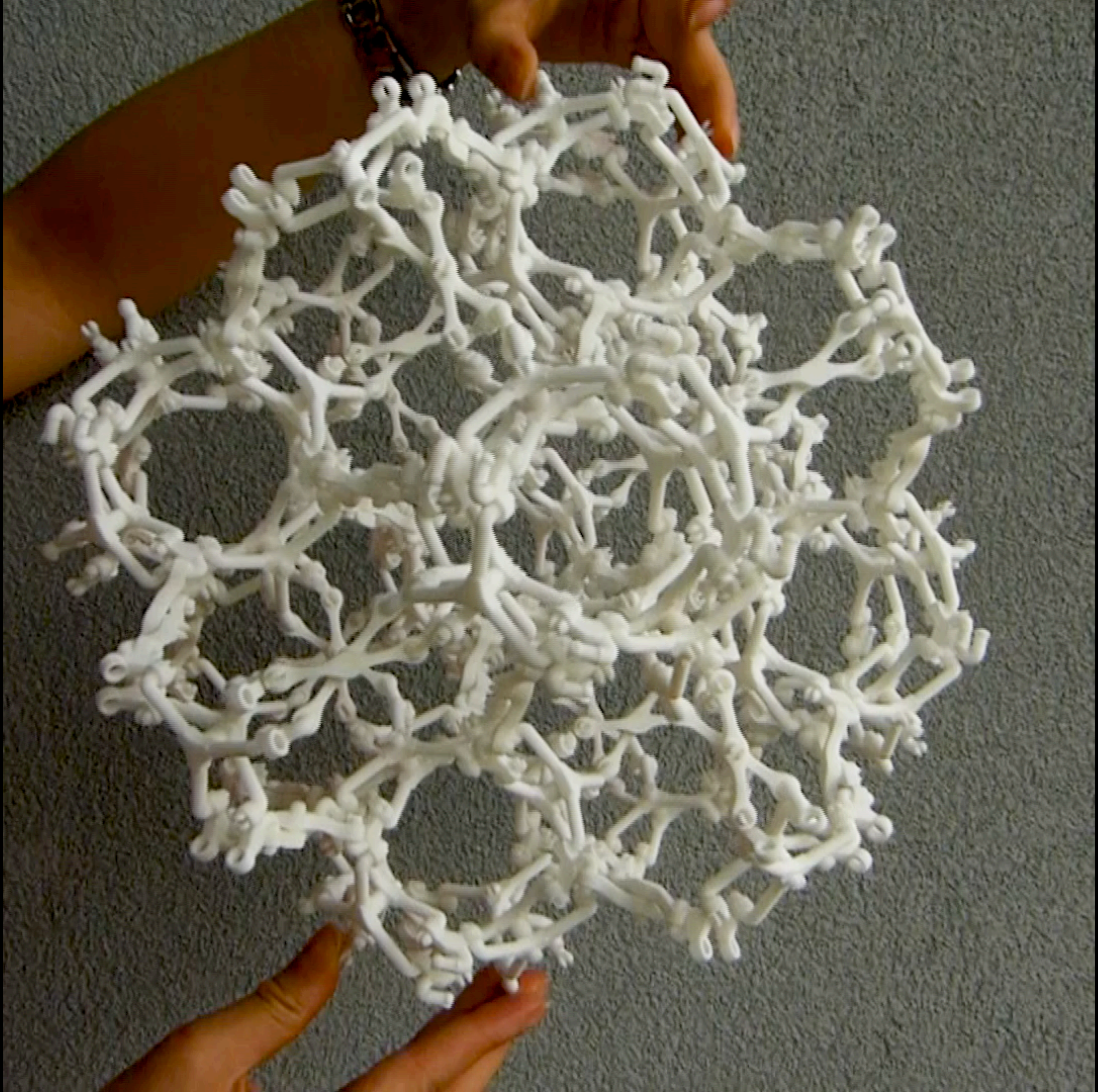
Octet/tatoh auxetic mechanism



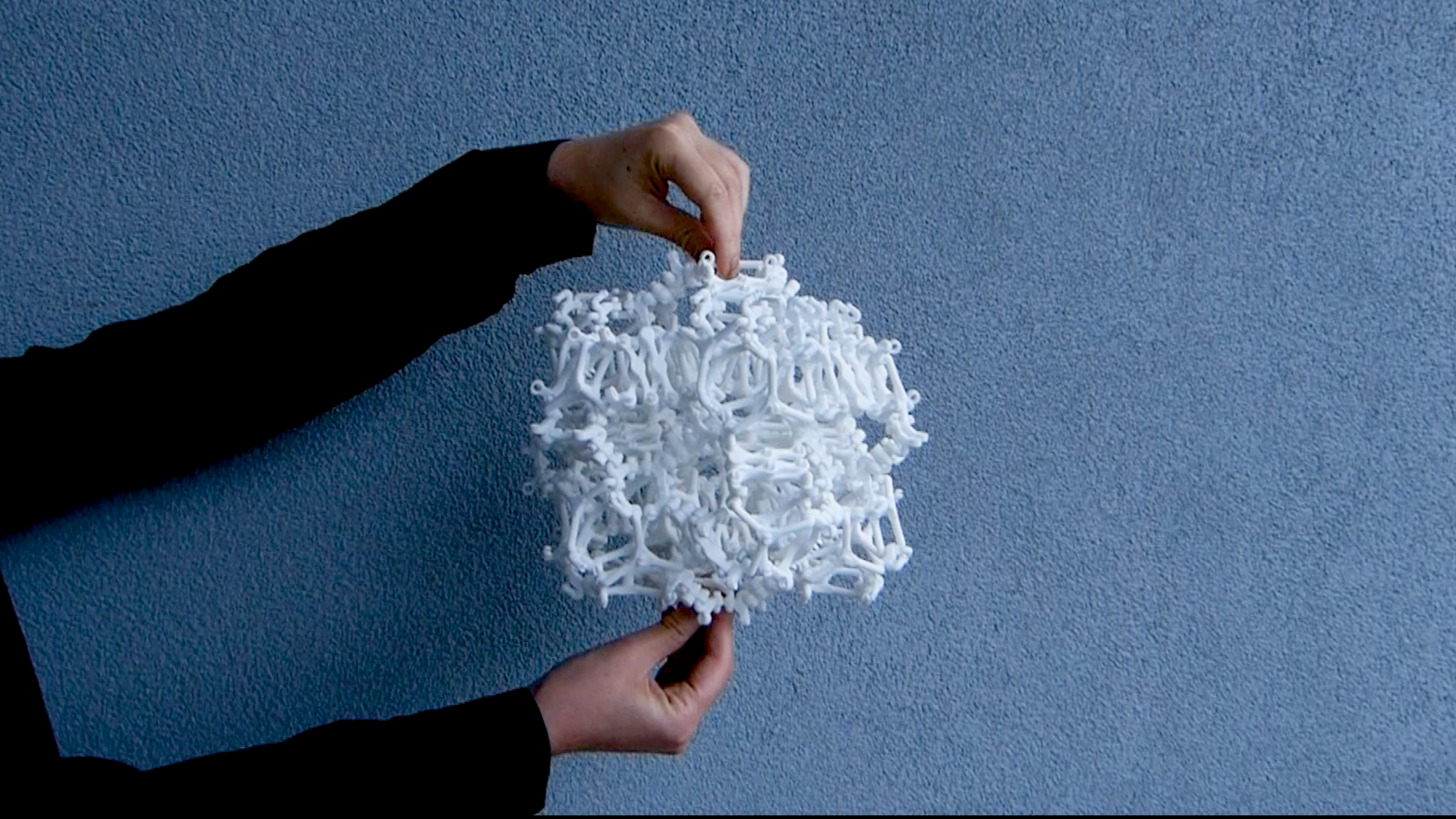
Octet/tatoh auxetic mechanism



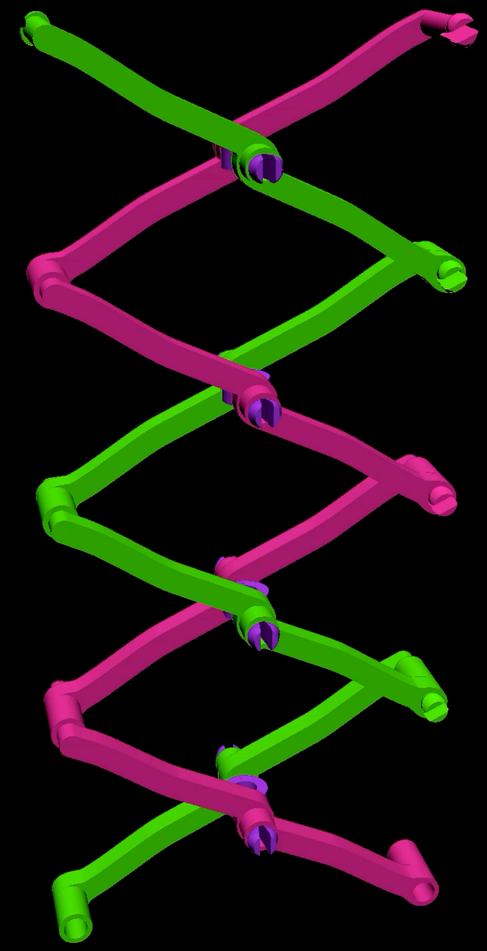
Joint work with Sabetta Matsumoto



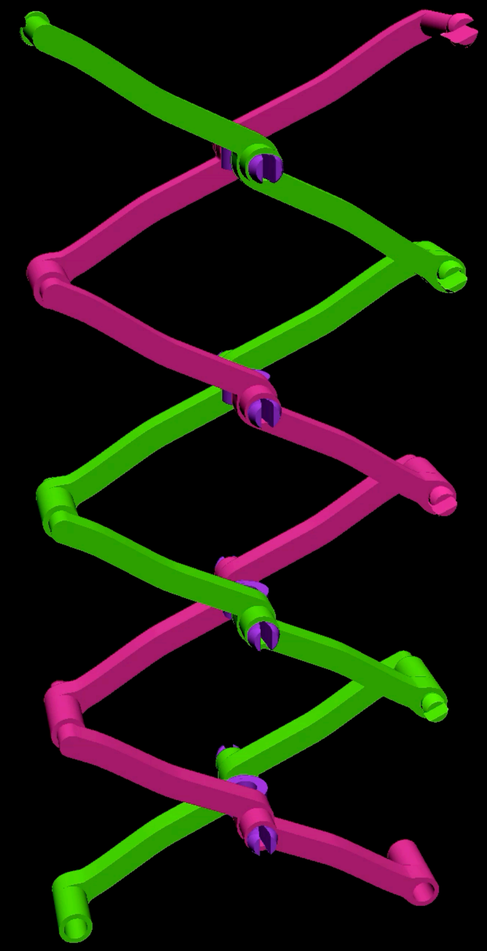
Joint work with Sabetta Matsumoto



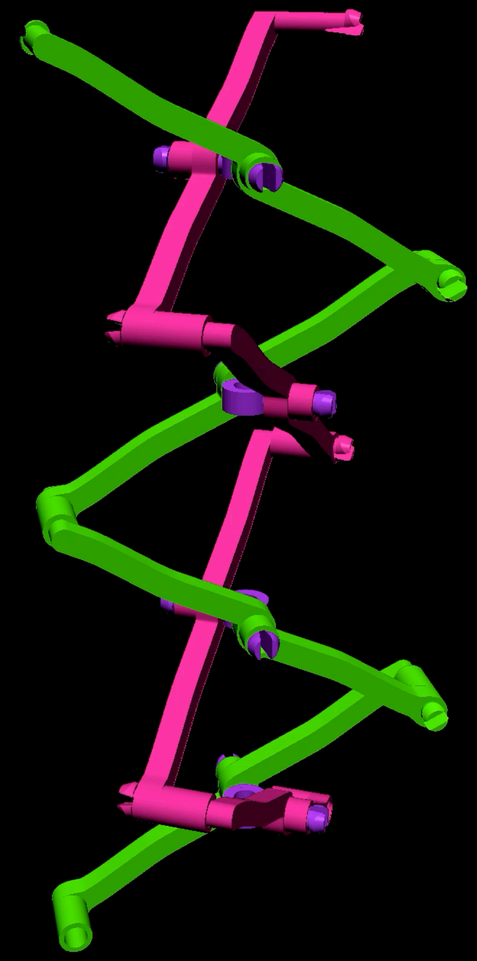
3. Branched scissor linkages



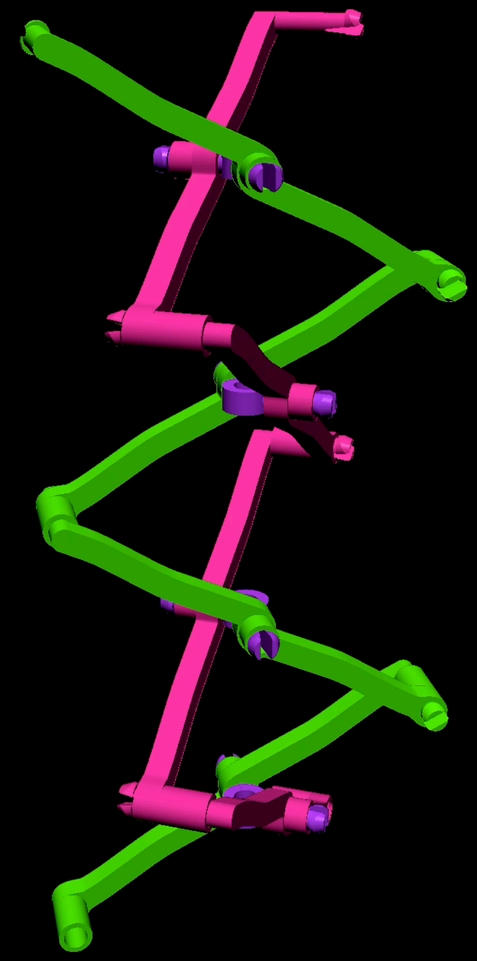
3. Branched scissor linkages



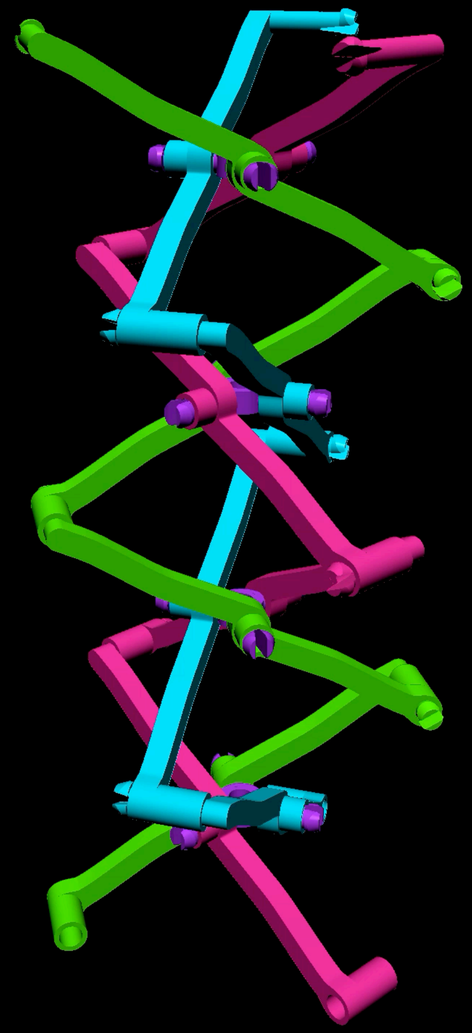
3. Branched scissor linkages



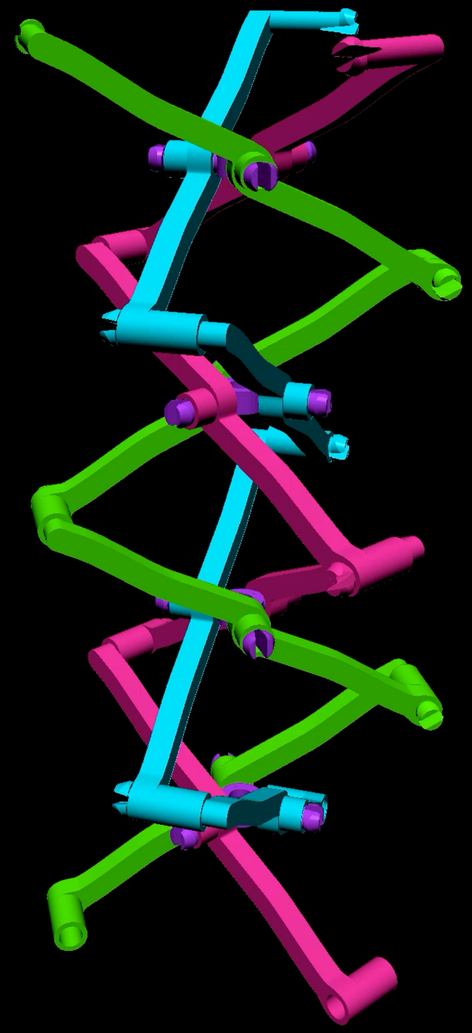
3. Branched scissor linkages



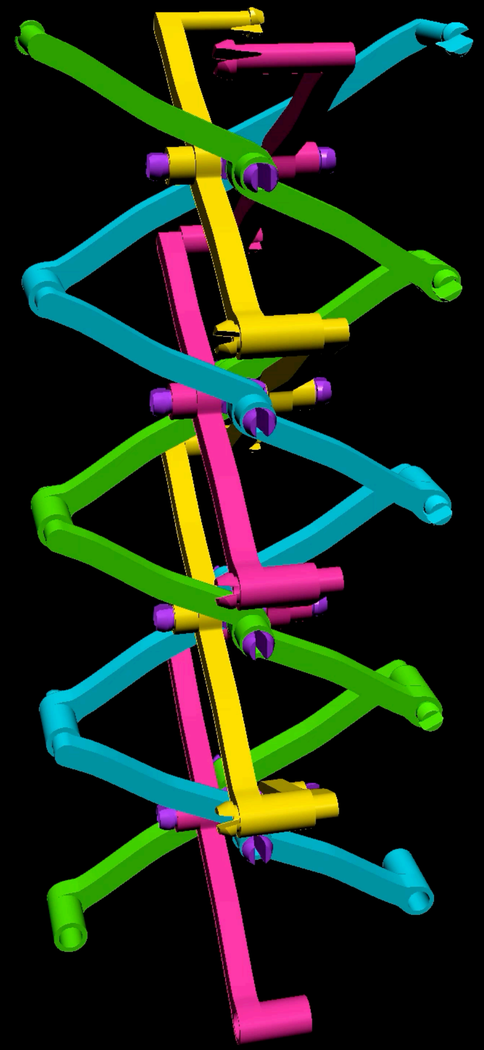
3. Branched scissor linkages



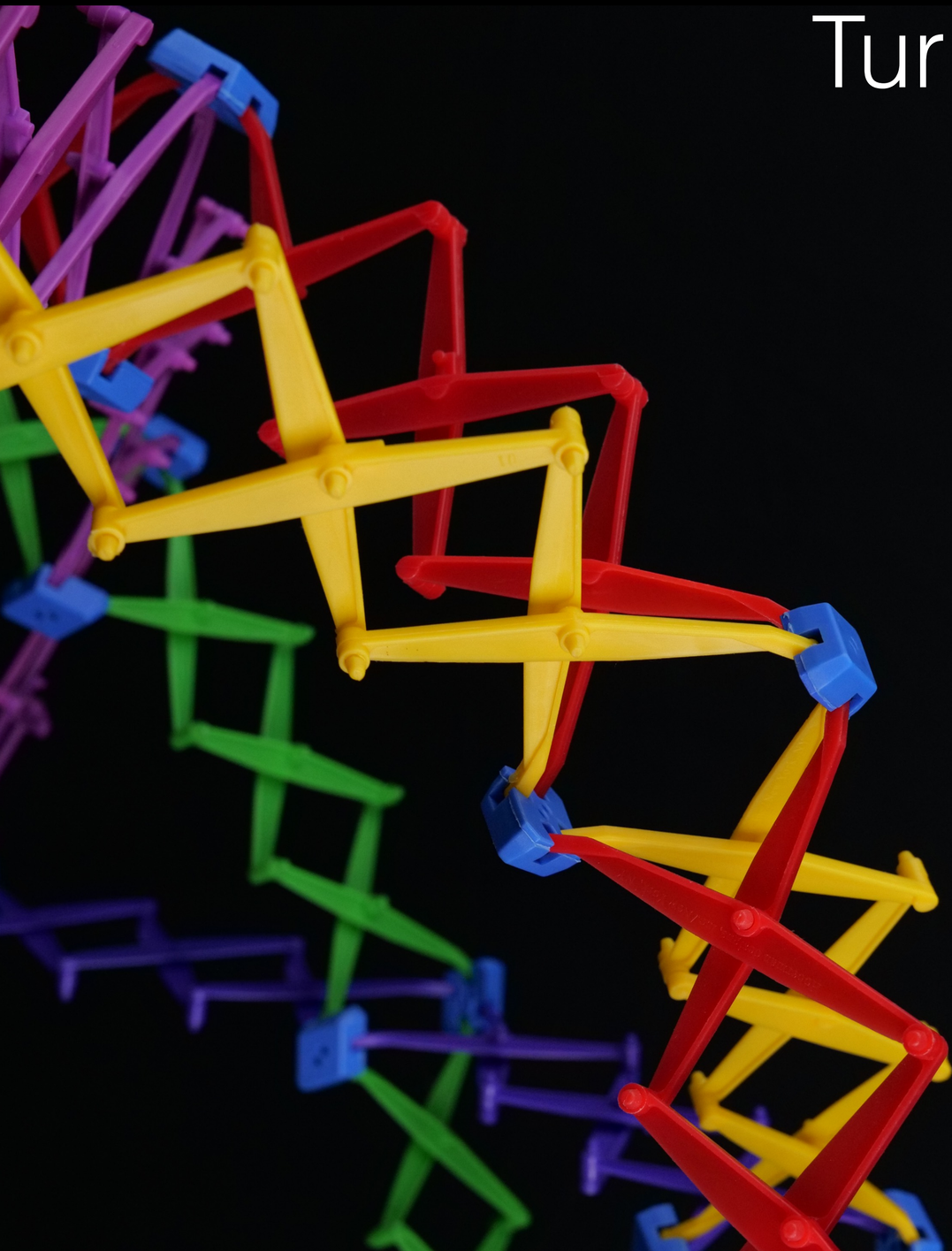
3. Branched scissor linkages

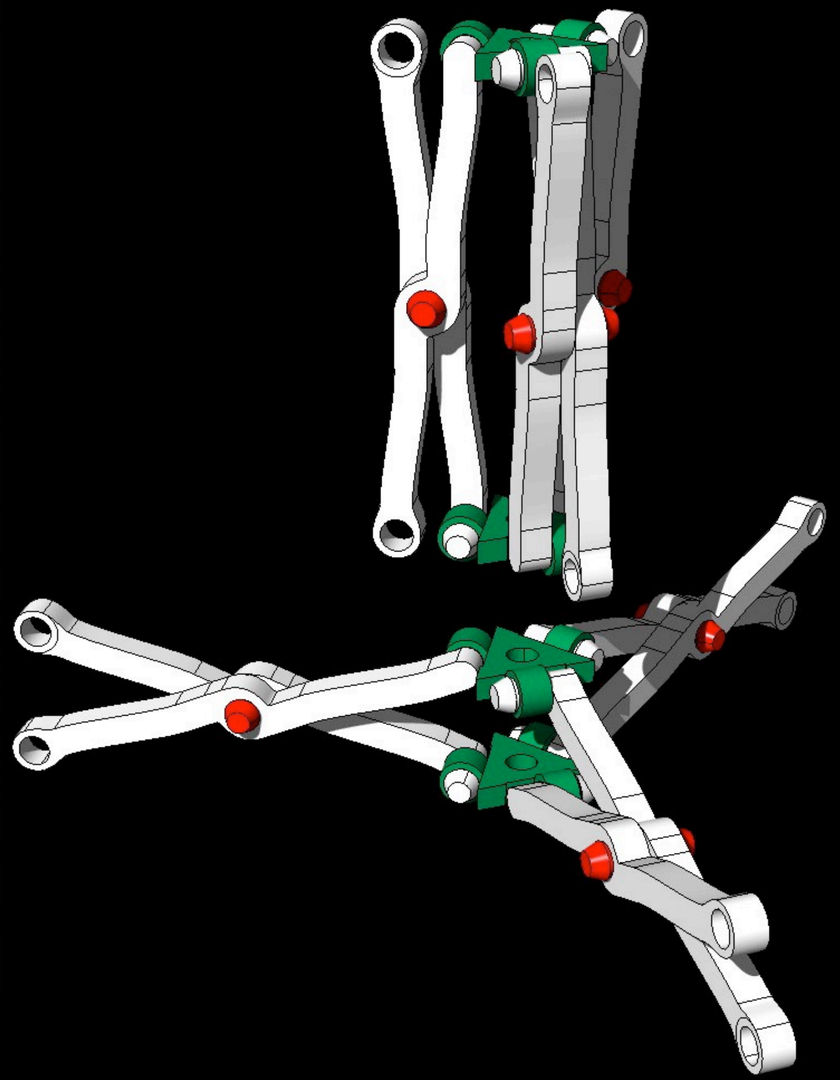


3. Branched scissor linkages

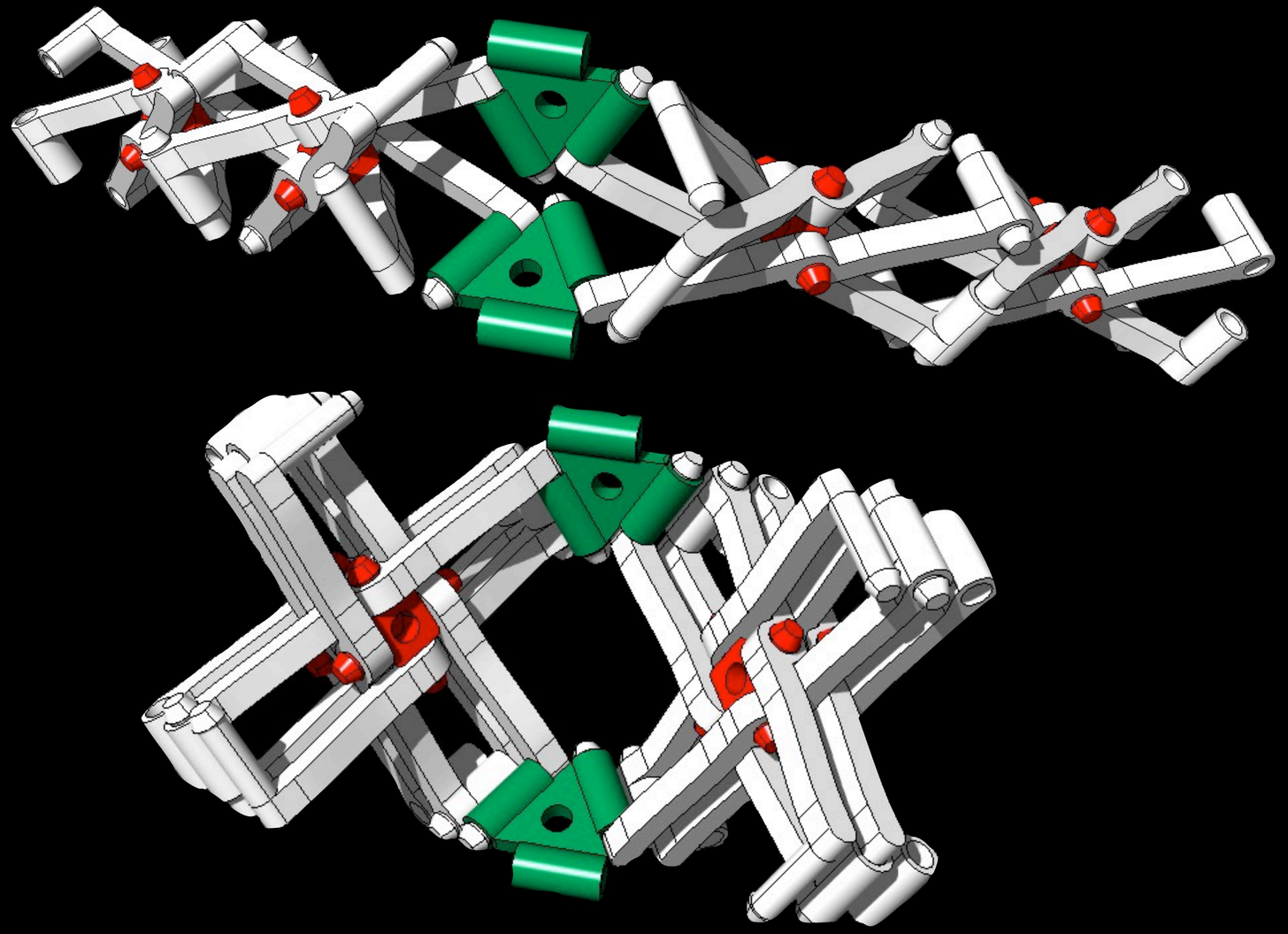


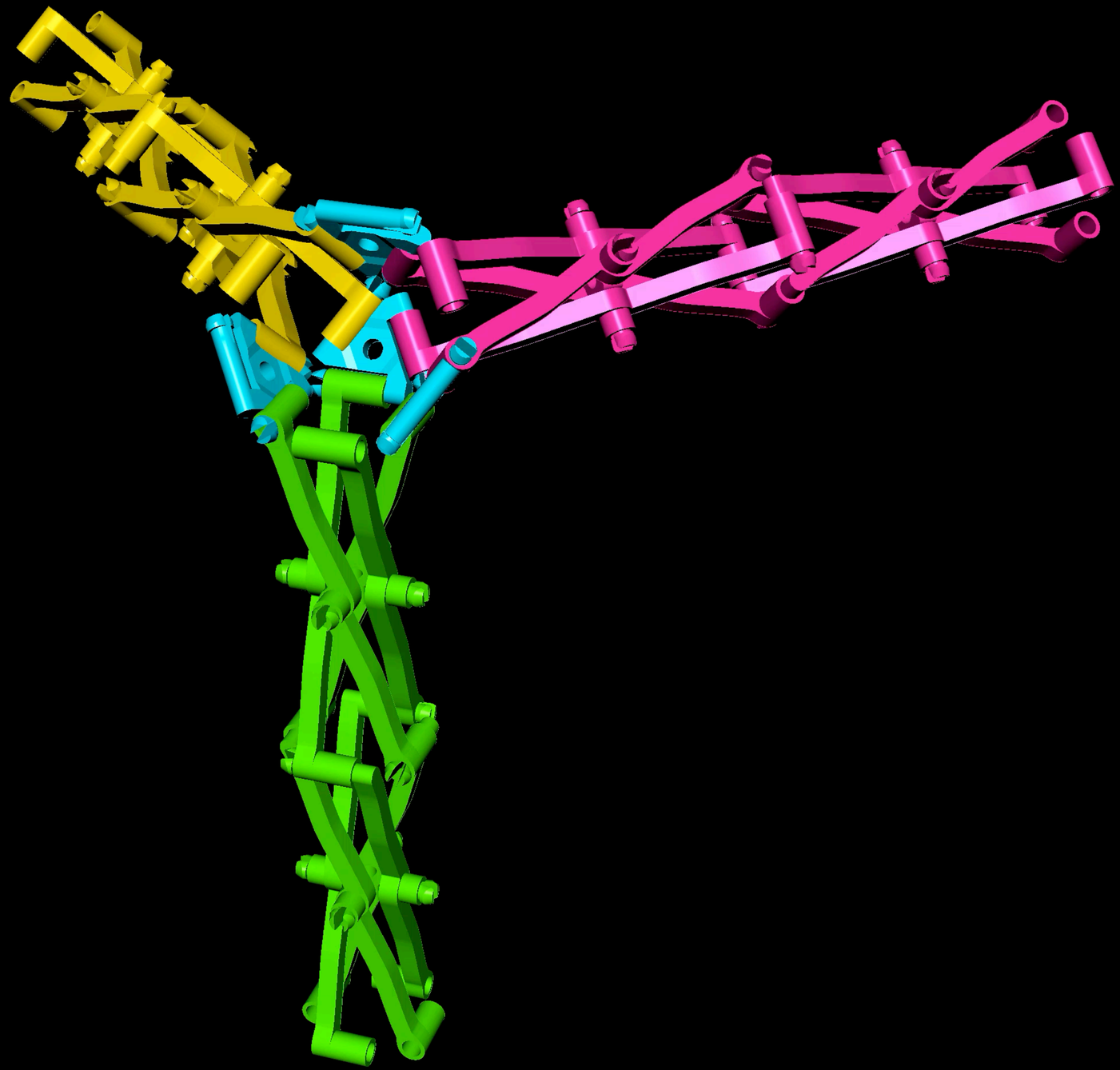
Turning corners with scissor linkages

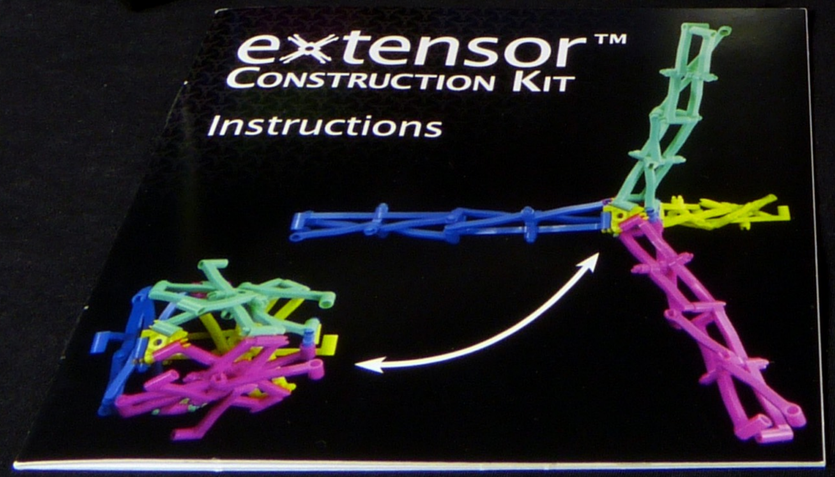




Turning corners with branched scissor linkages

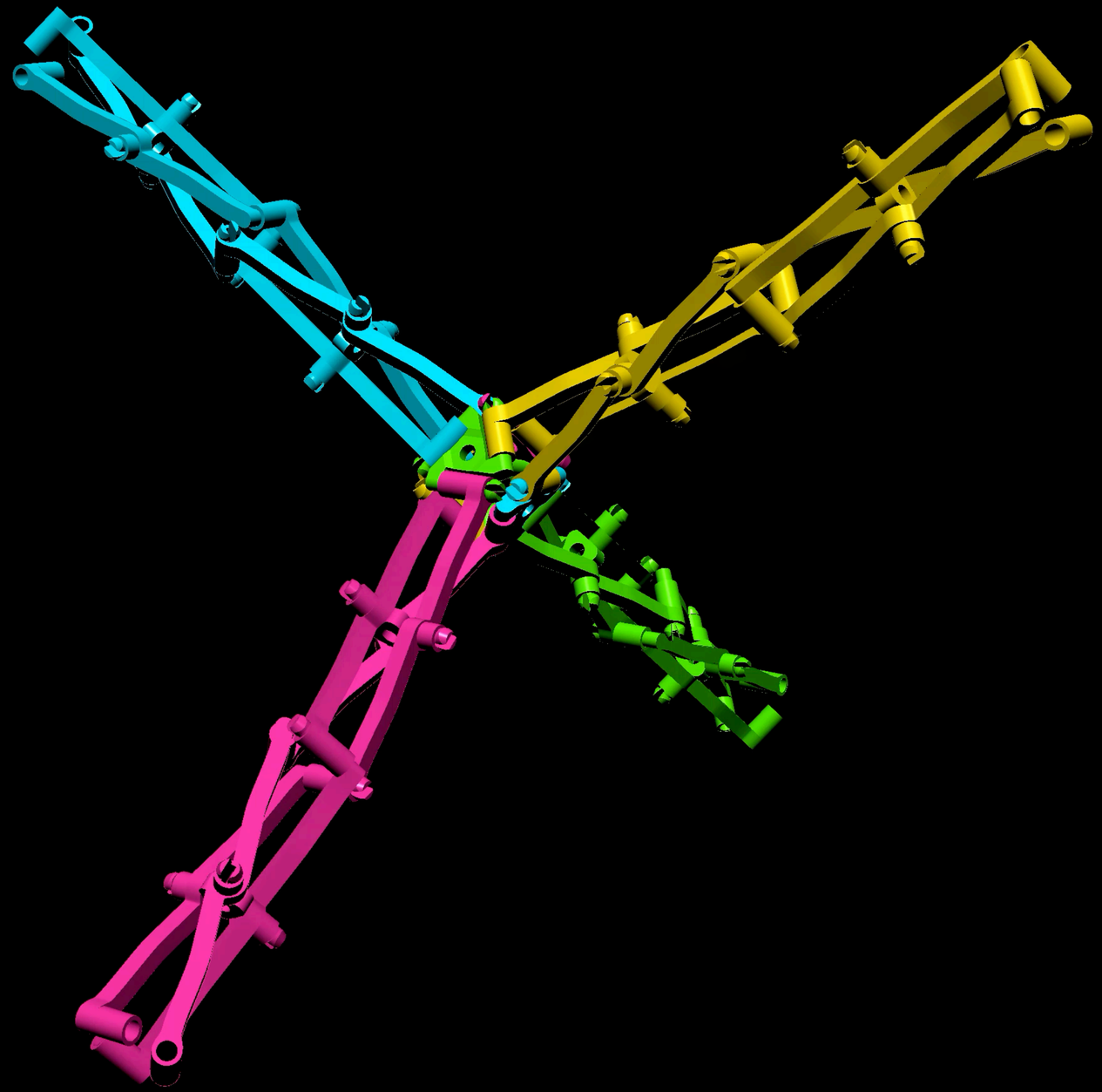




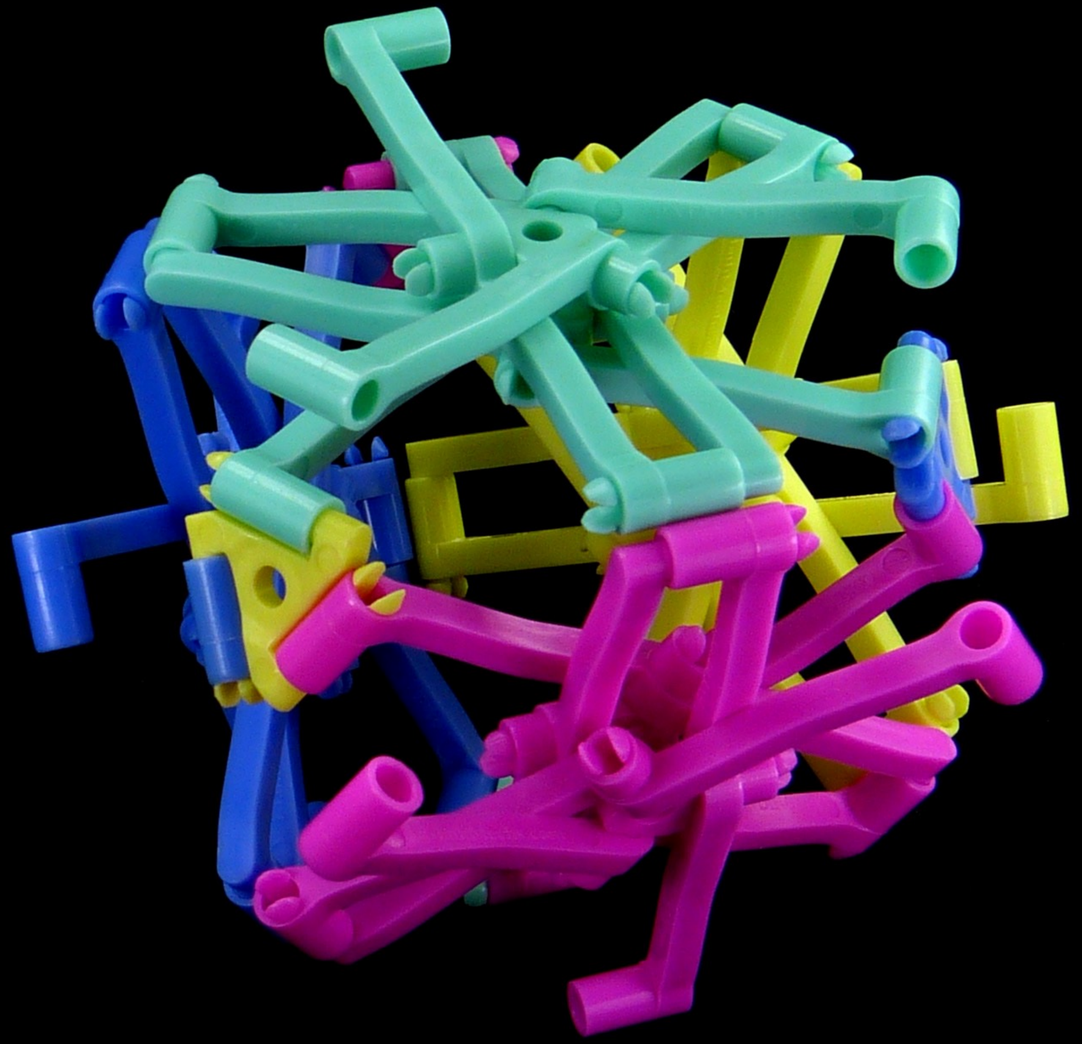


Available from MathMechs.com

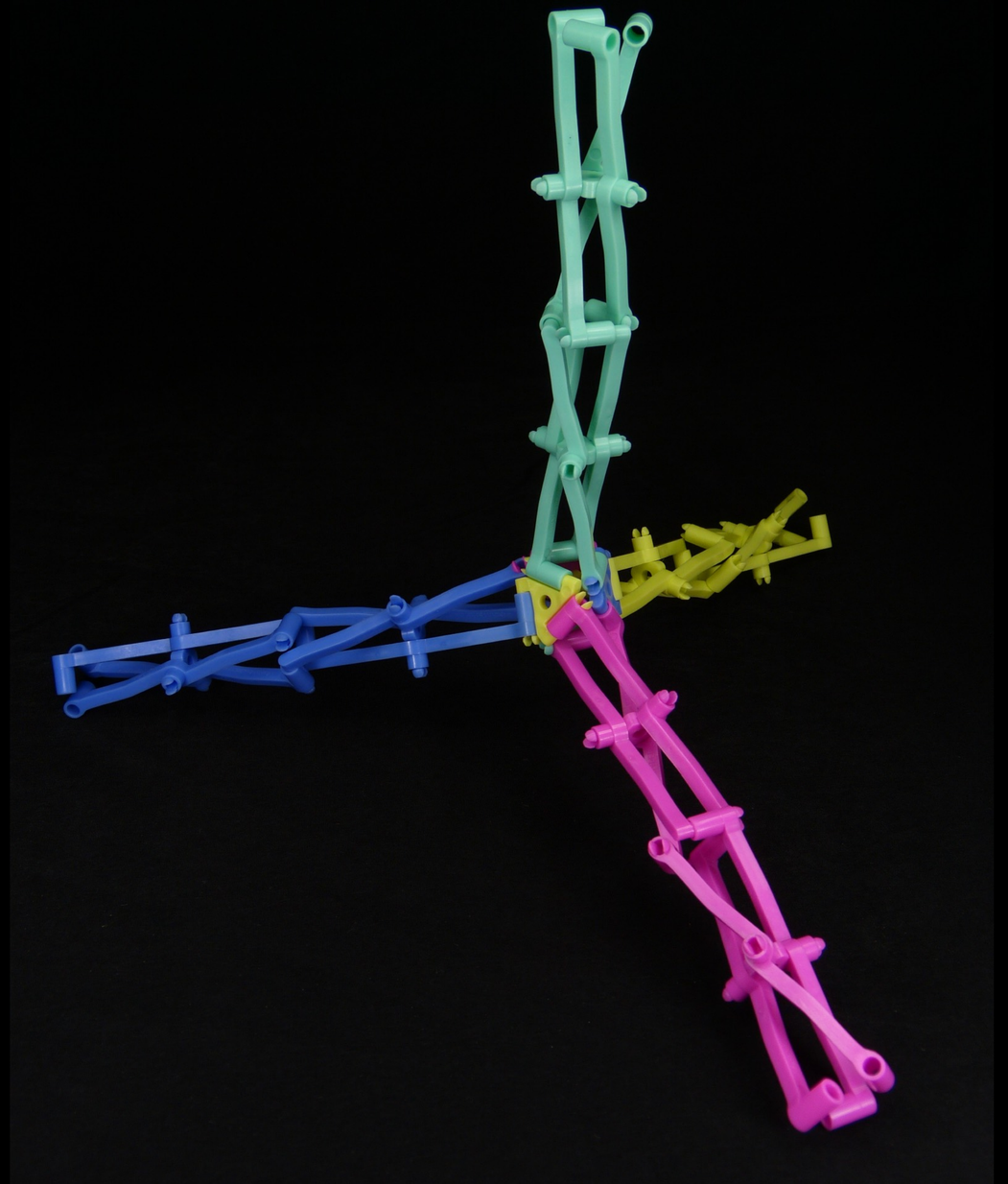

Music: MkVaff - Tetris 'McVaffeQuasi Ultimix' OC ReMix

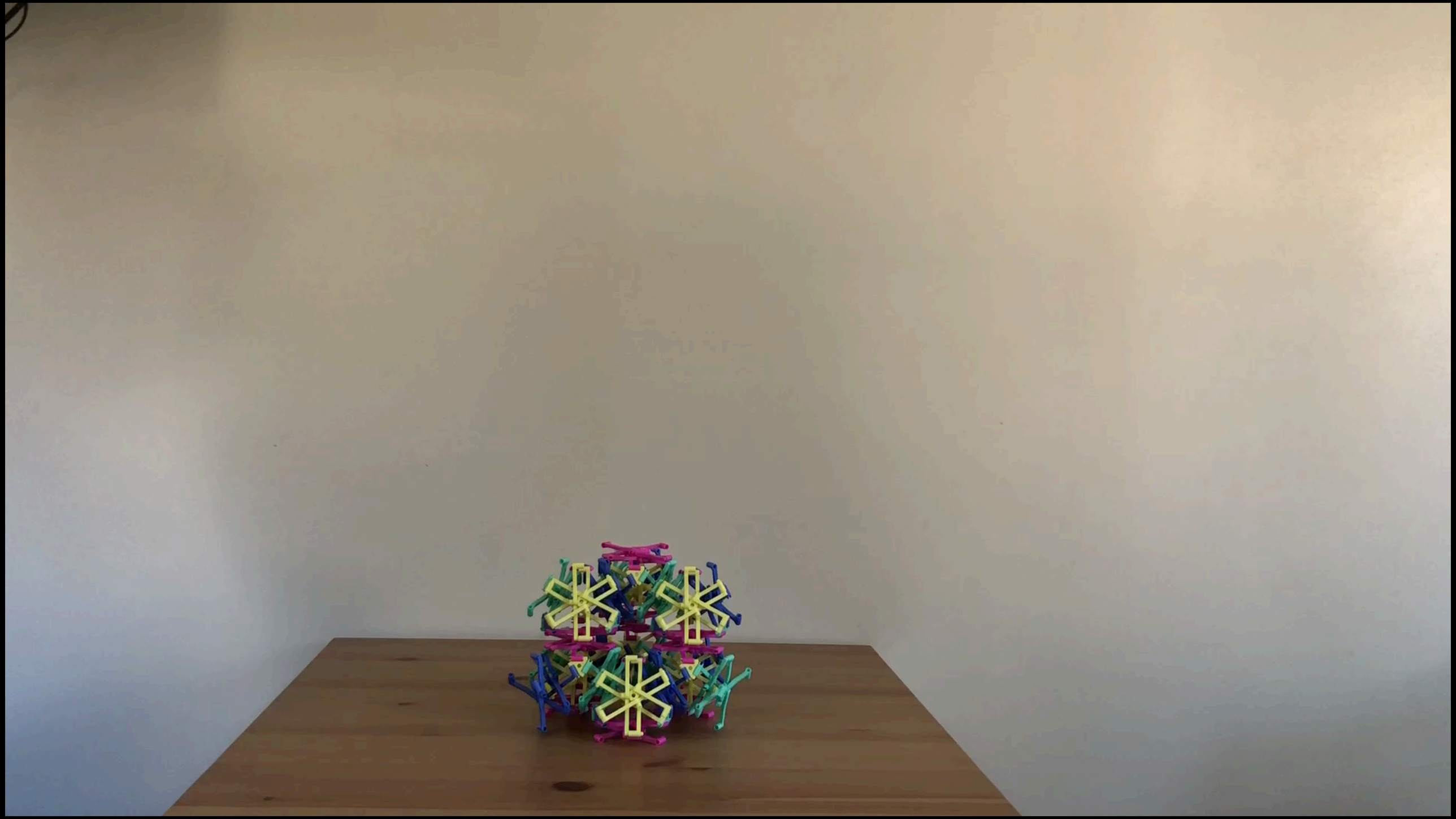


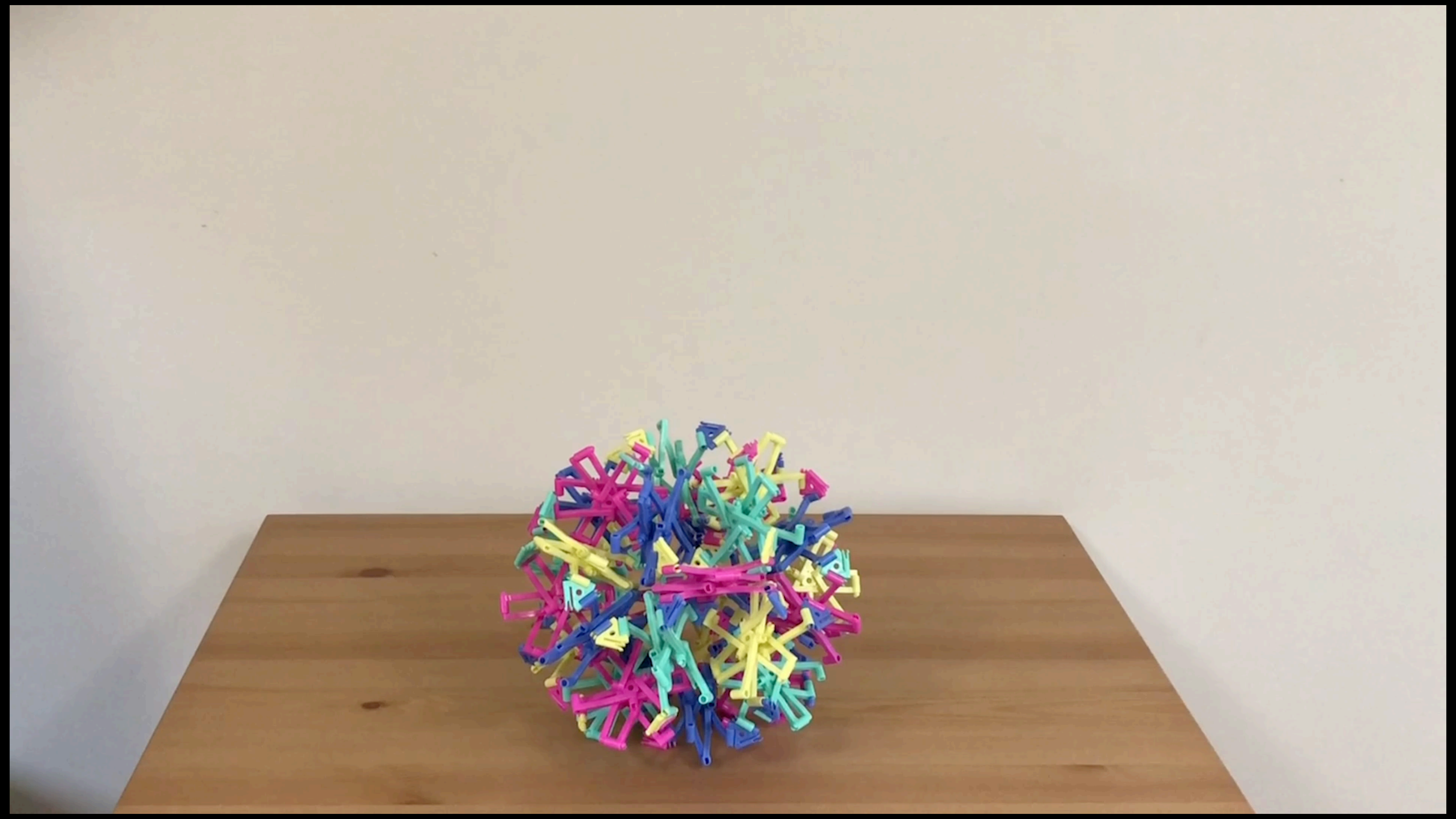
Branched scissor caltrop



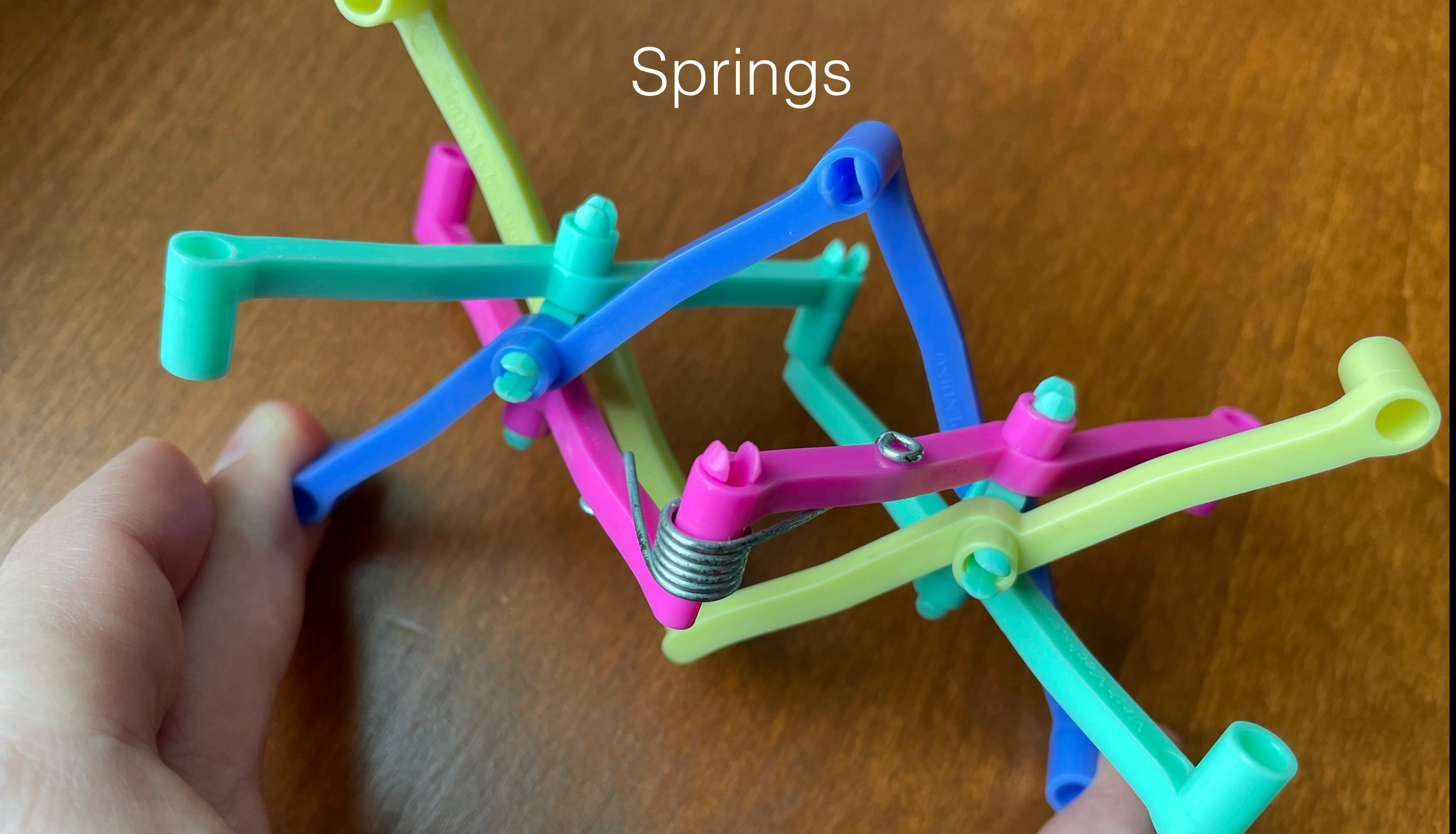
Branched scissor caltrop





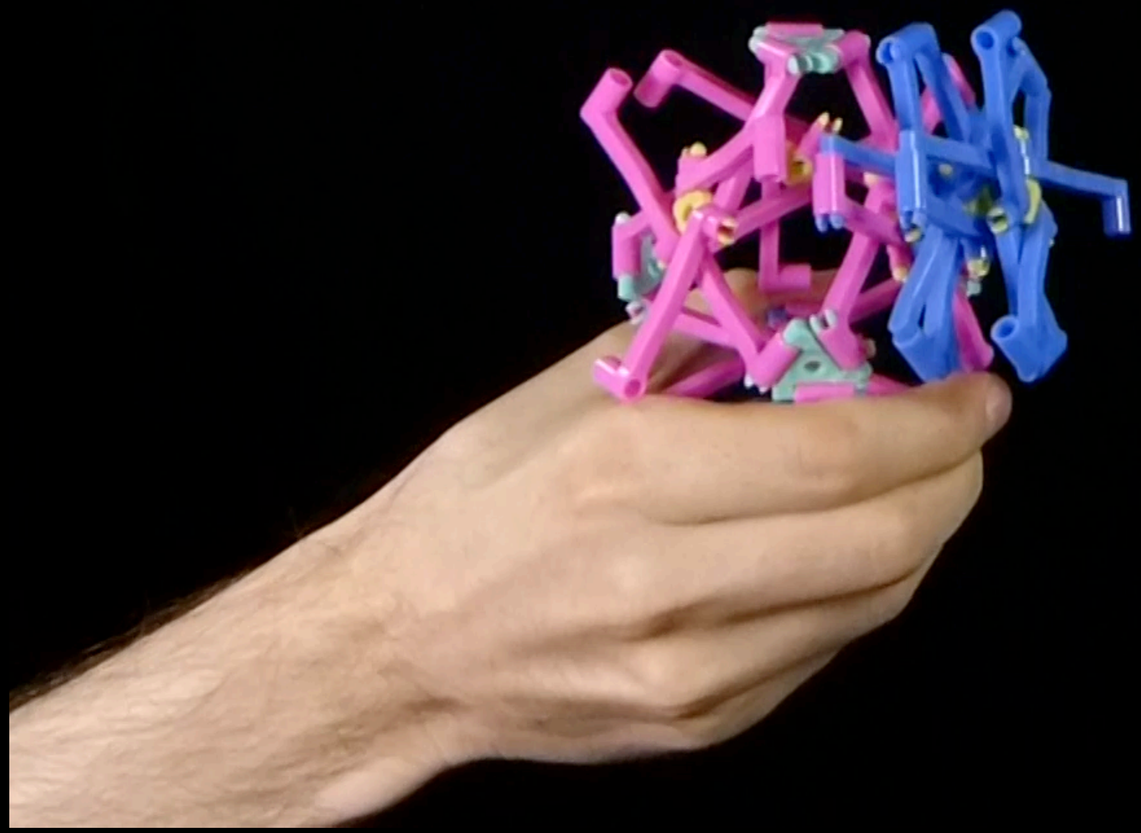


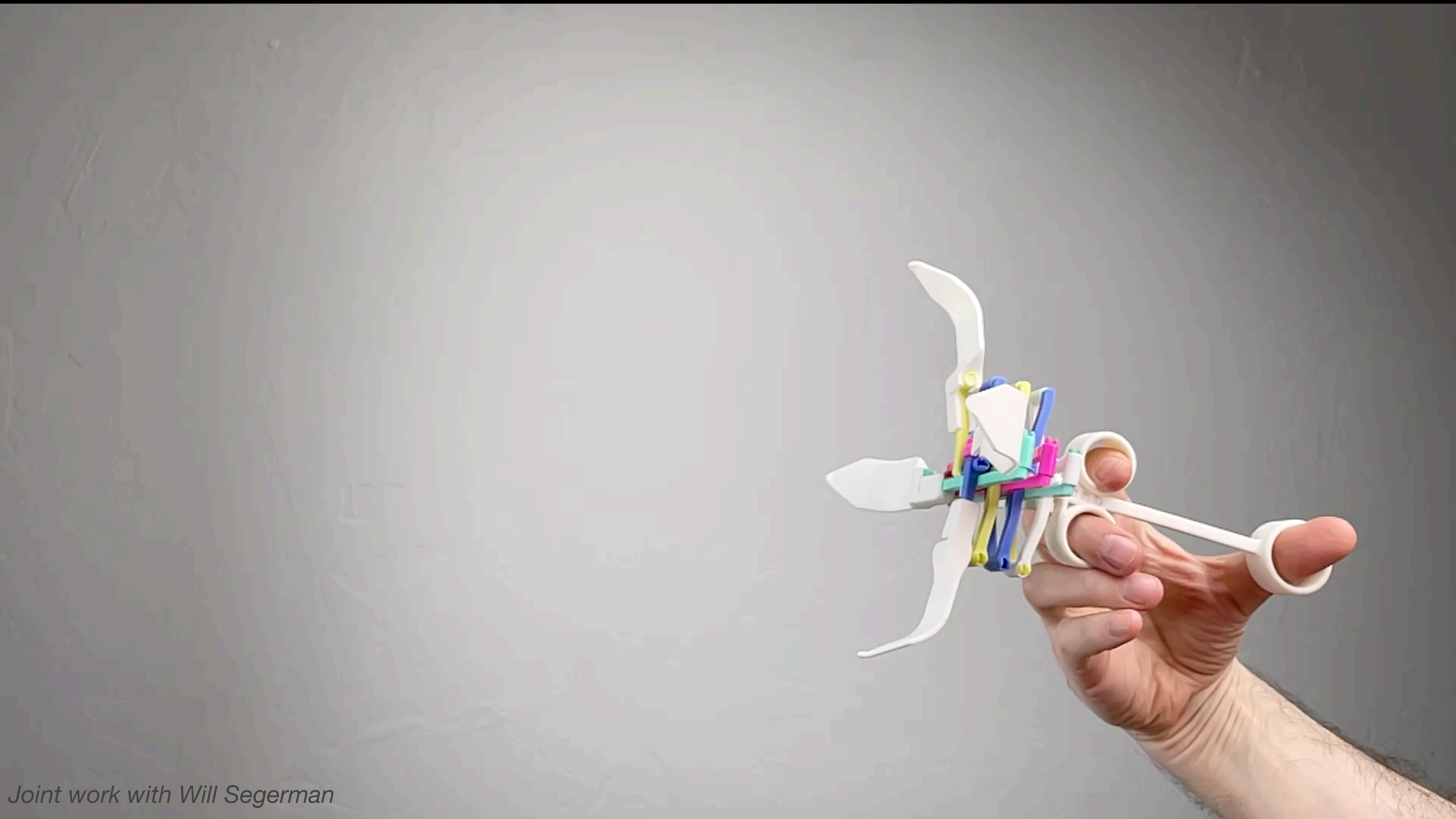
Springs



MathMechs.com

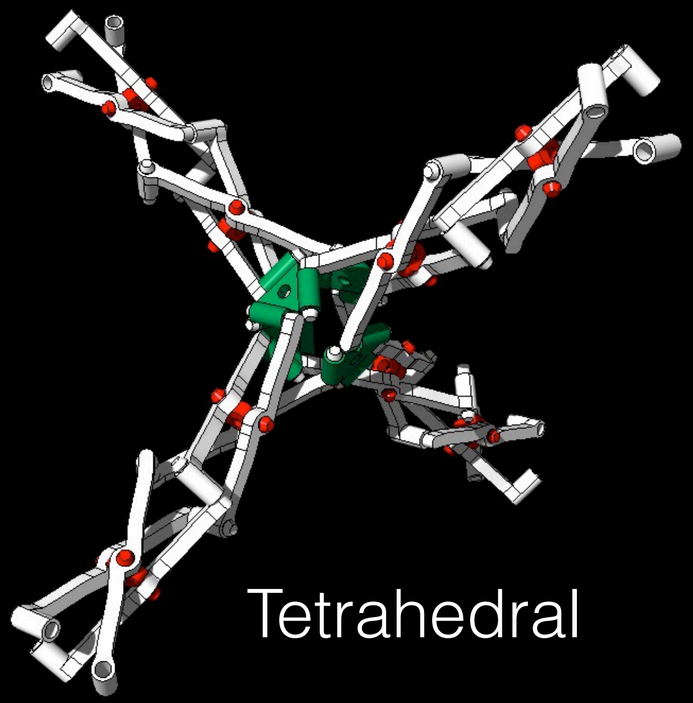
Springs



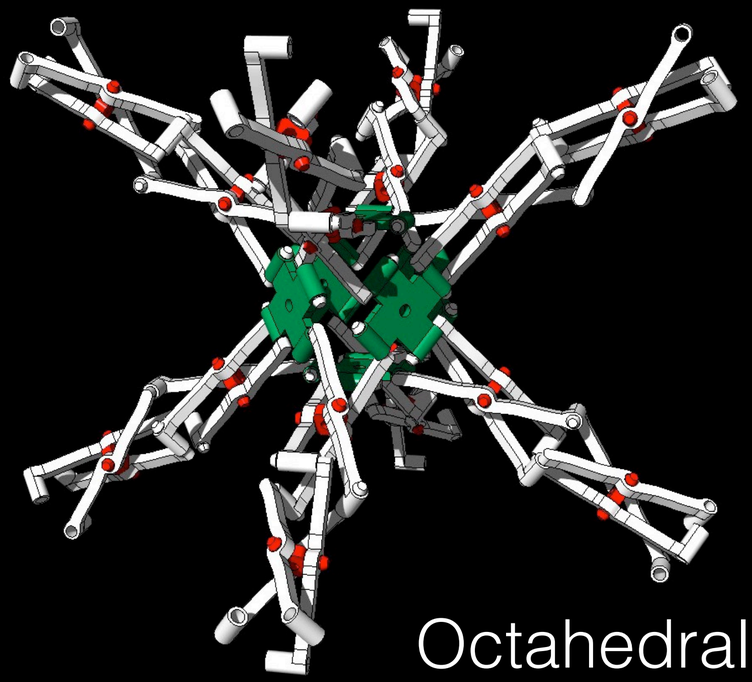


Joint work with Will Segerman

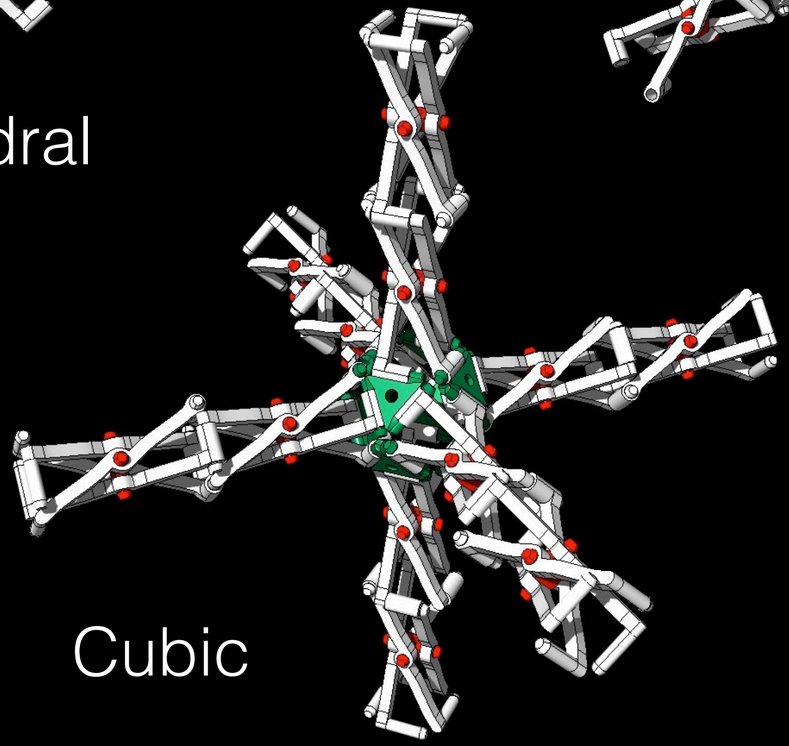
Non-planar vertex links



Tetrahedral

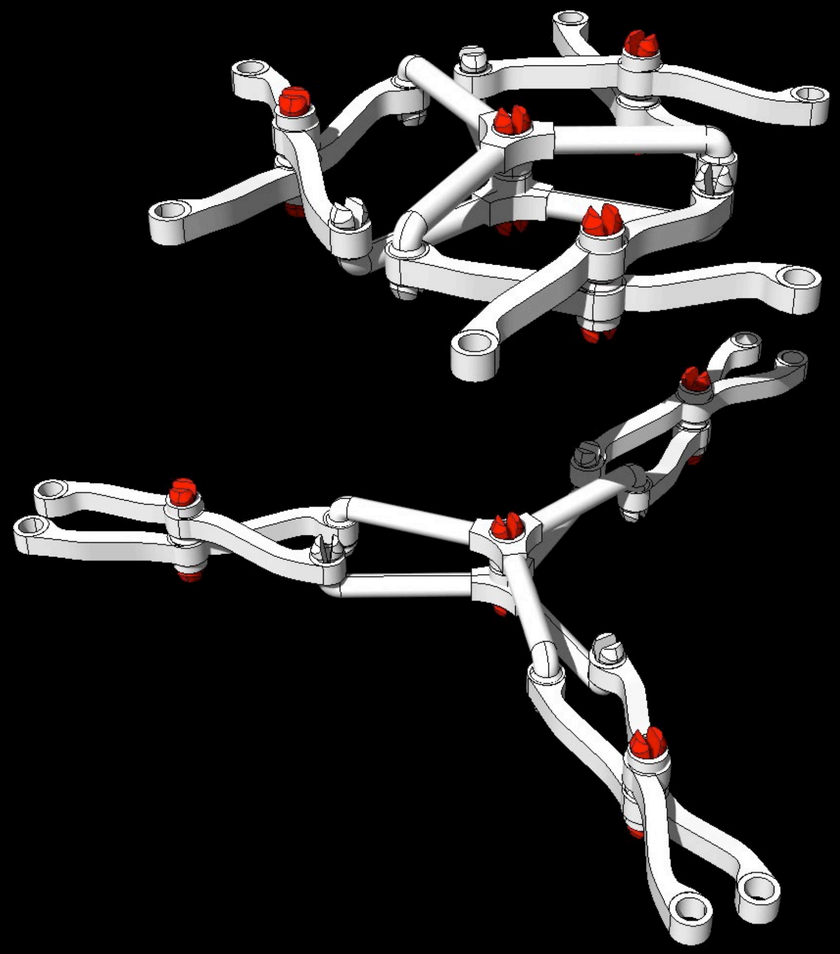


Octahedral

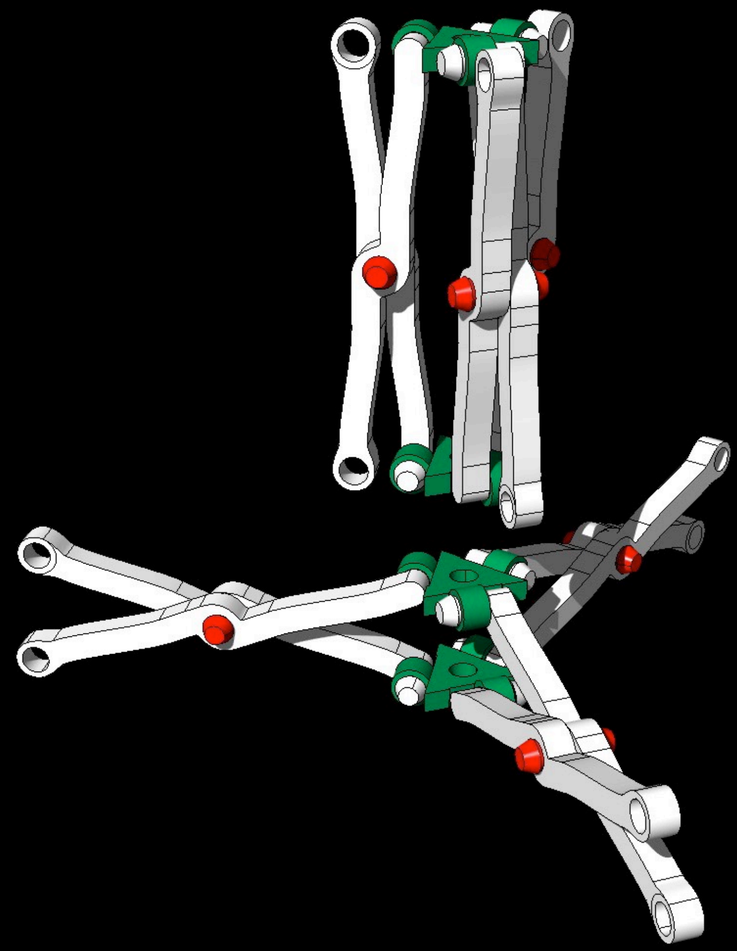


Cubic

Planar vertex links

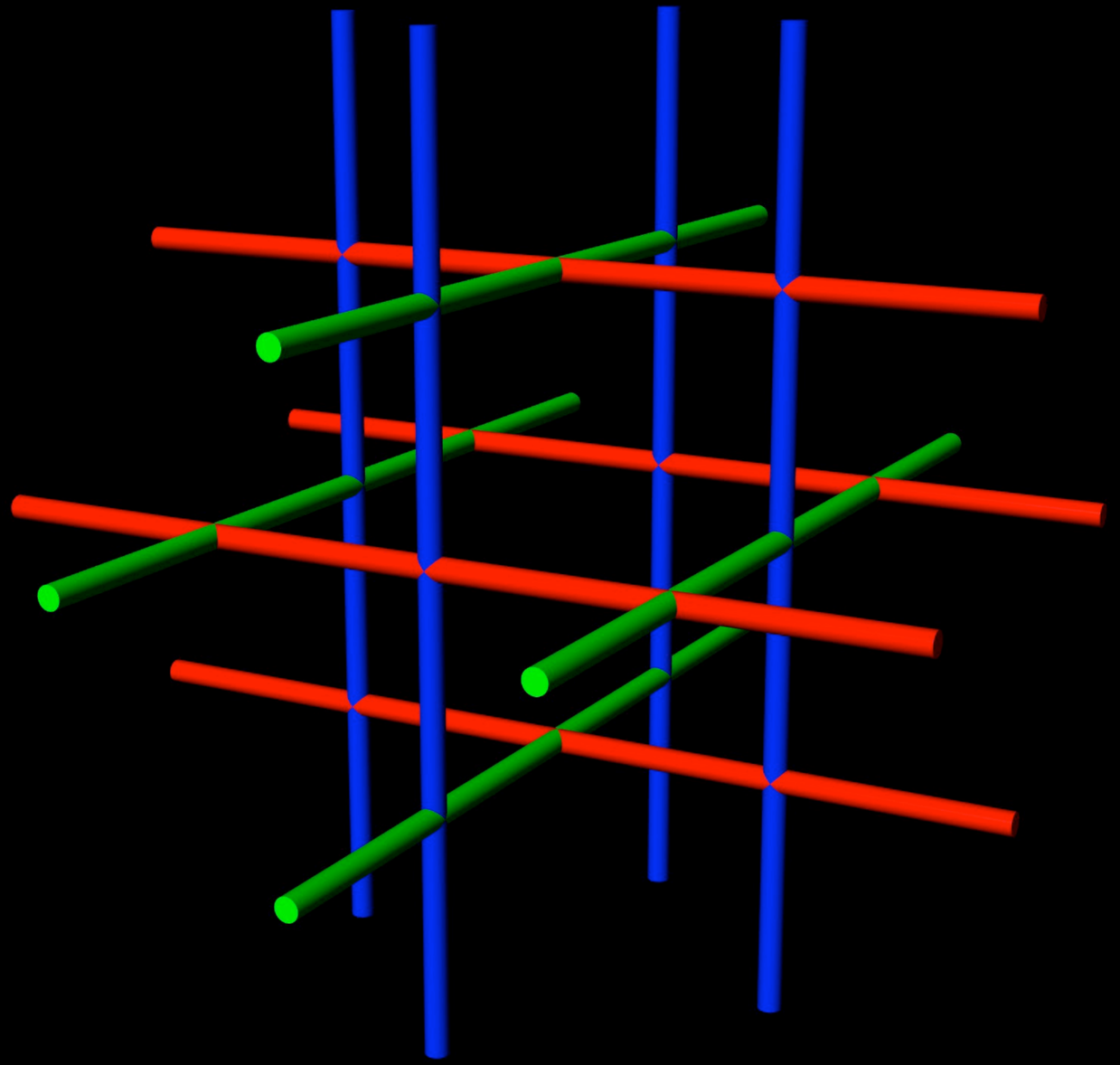


Counterrotating

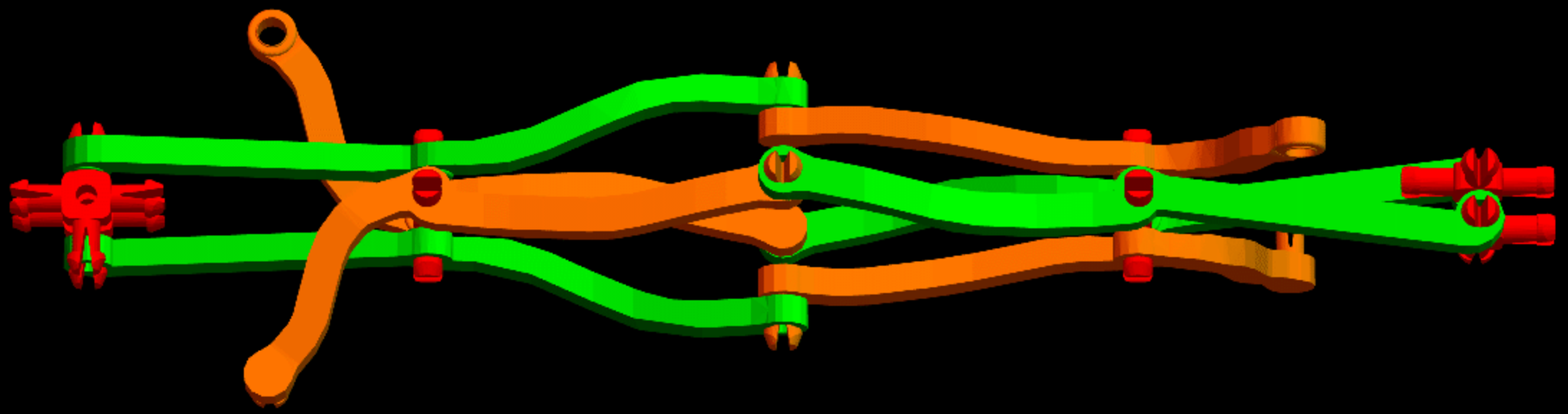


Hoberman

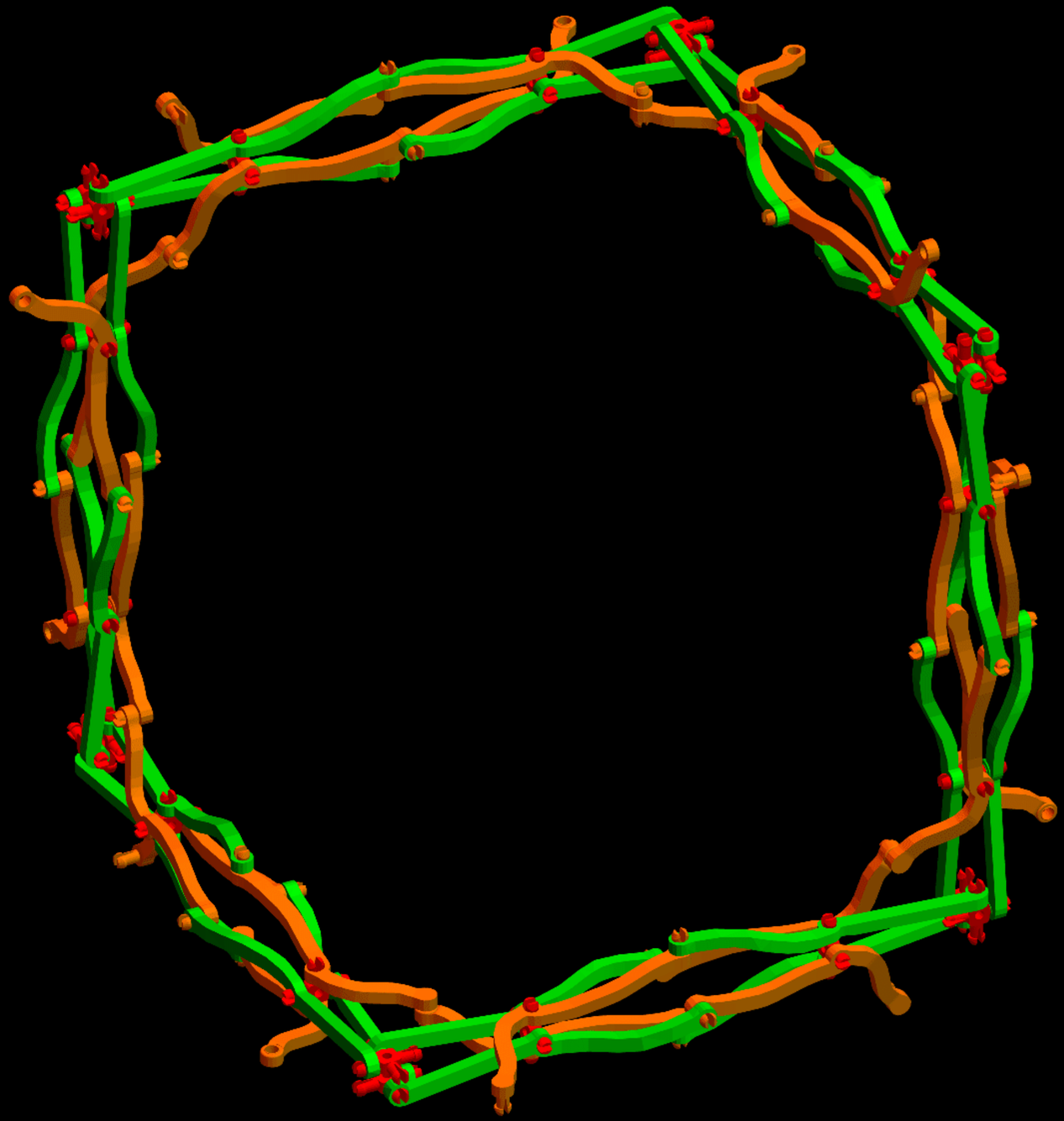
NbO lattice

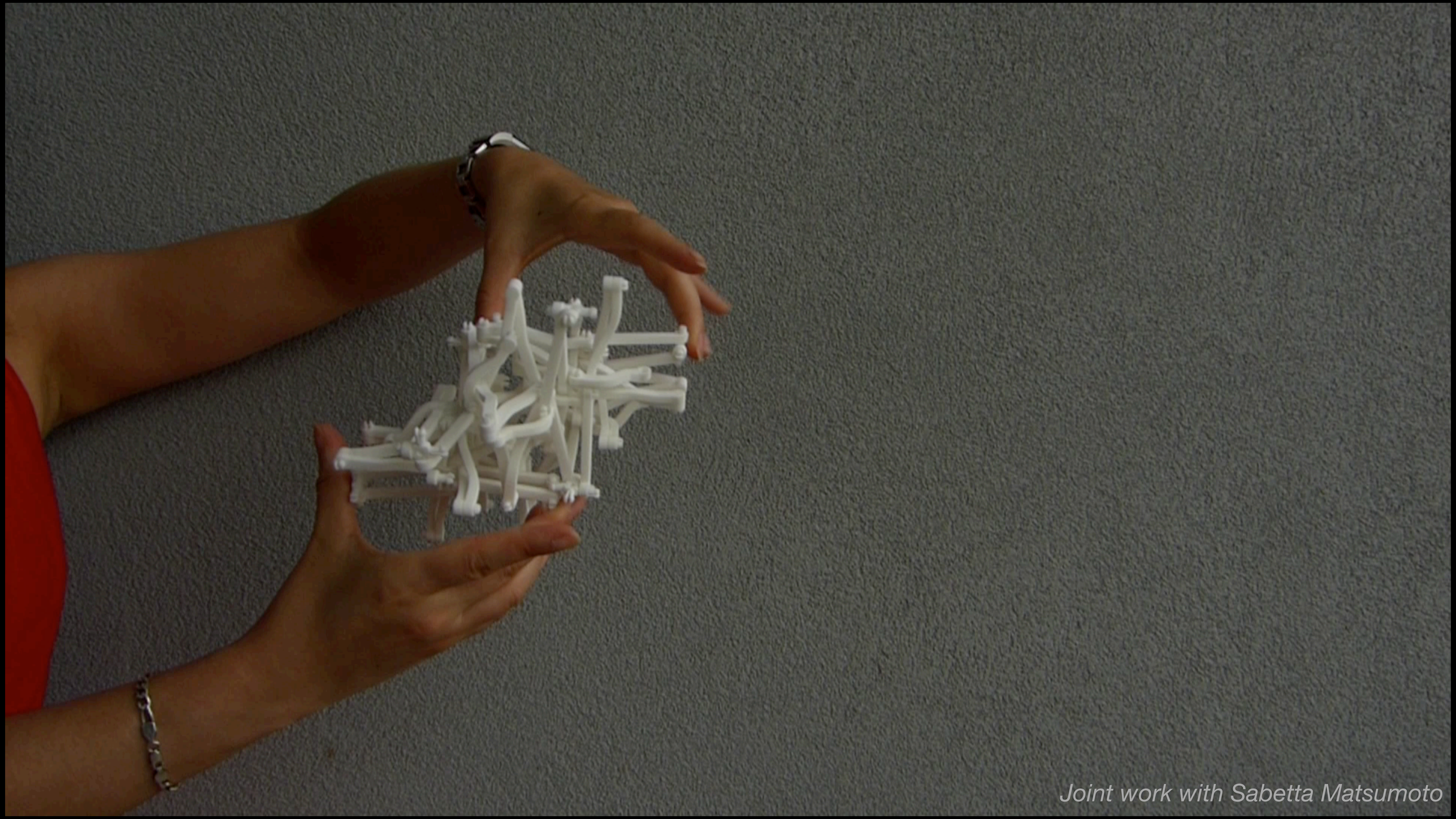


4. Auxetic NbO lattice

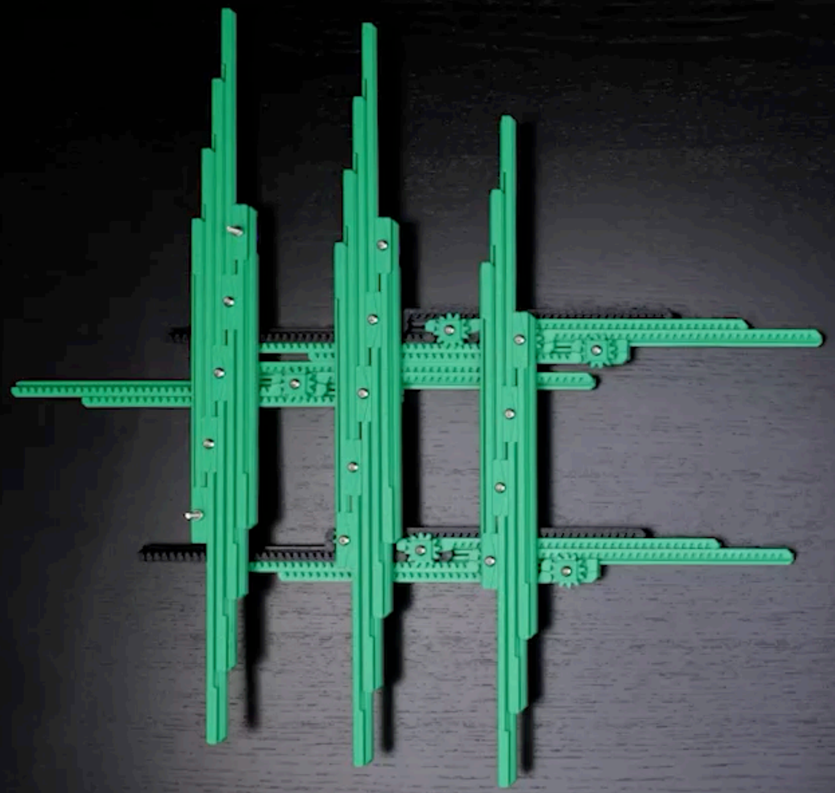


Joint work with Sabetta Matsumoto

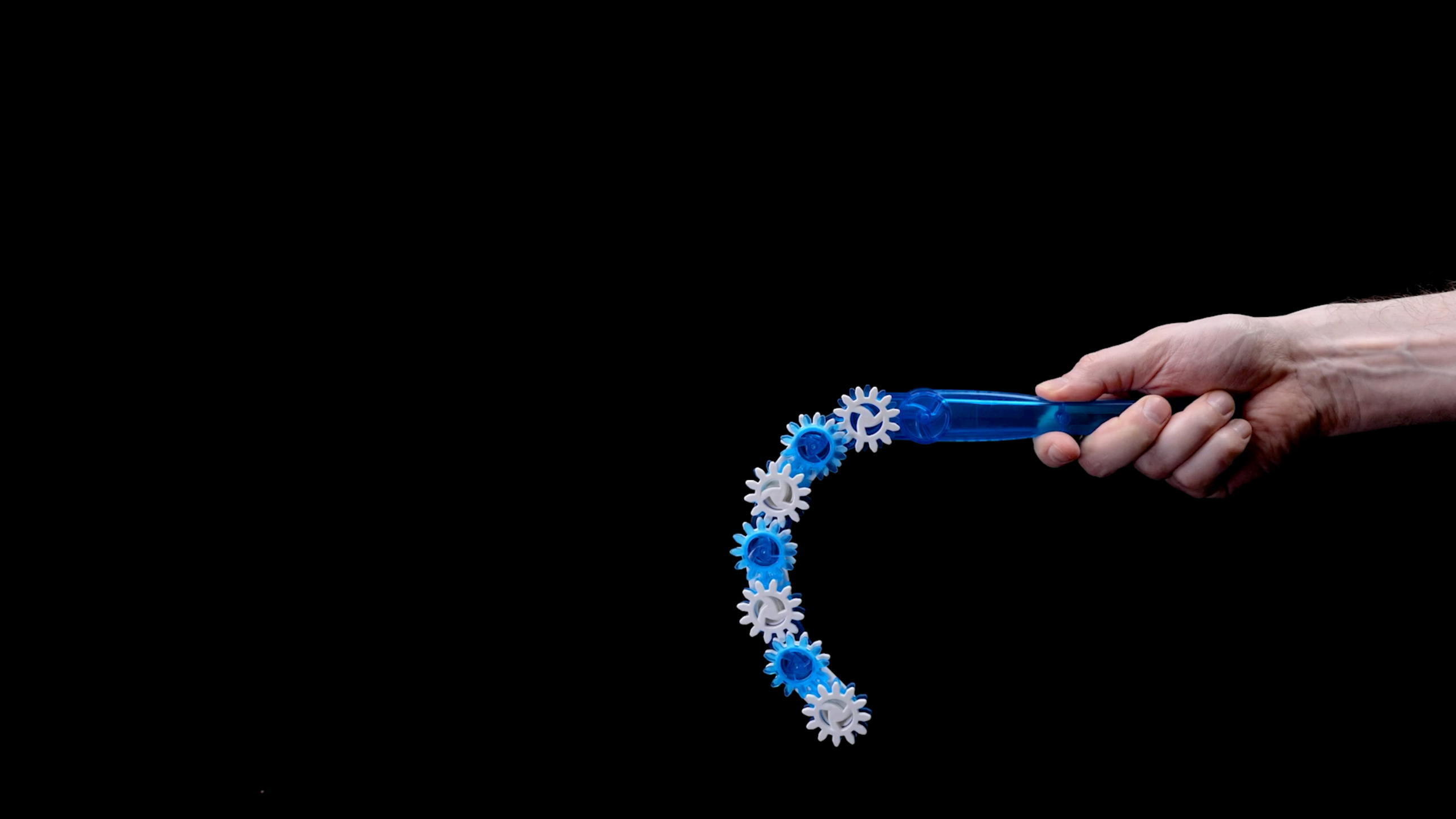


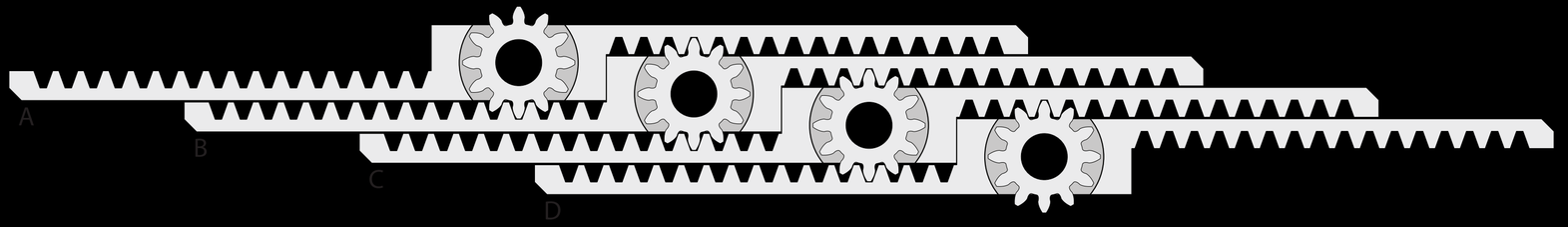

Joint work with Sabetta Matsumoto

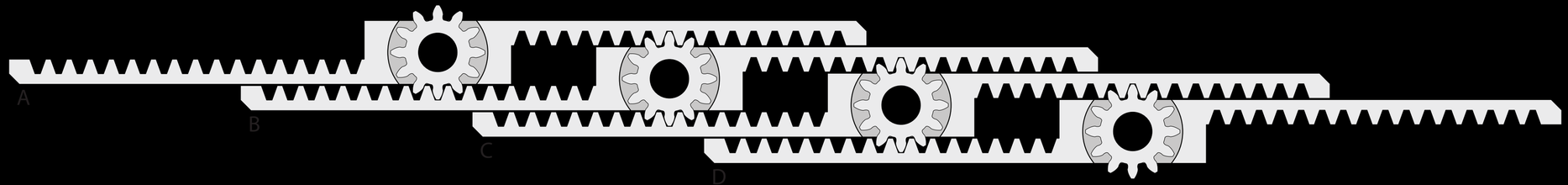
Rack and pinion mechanisms

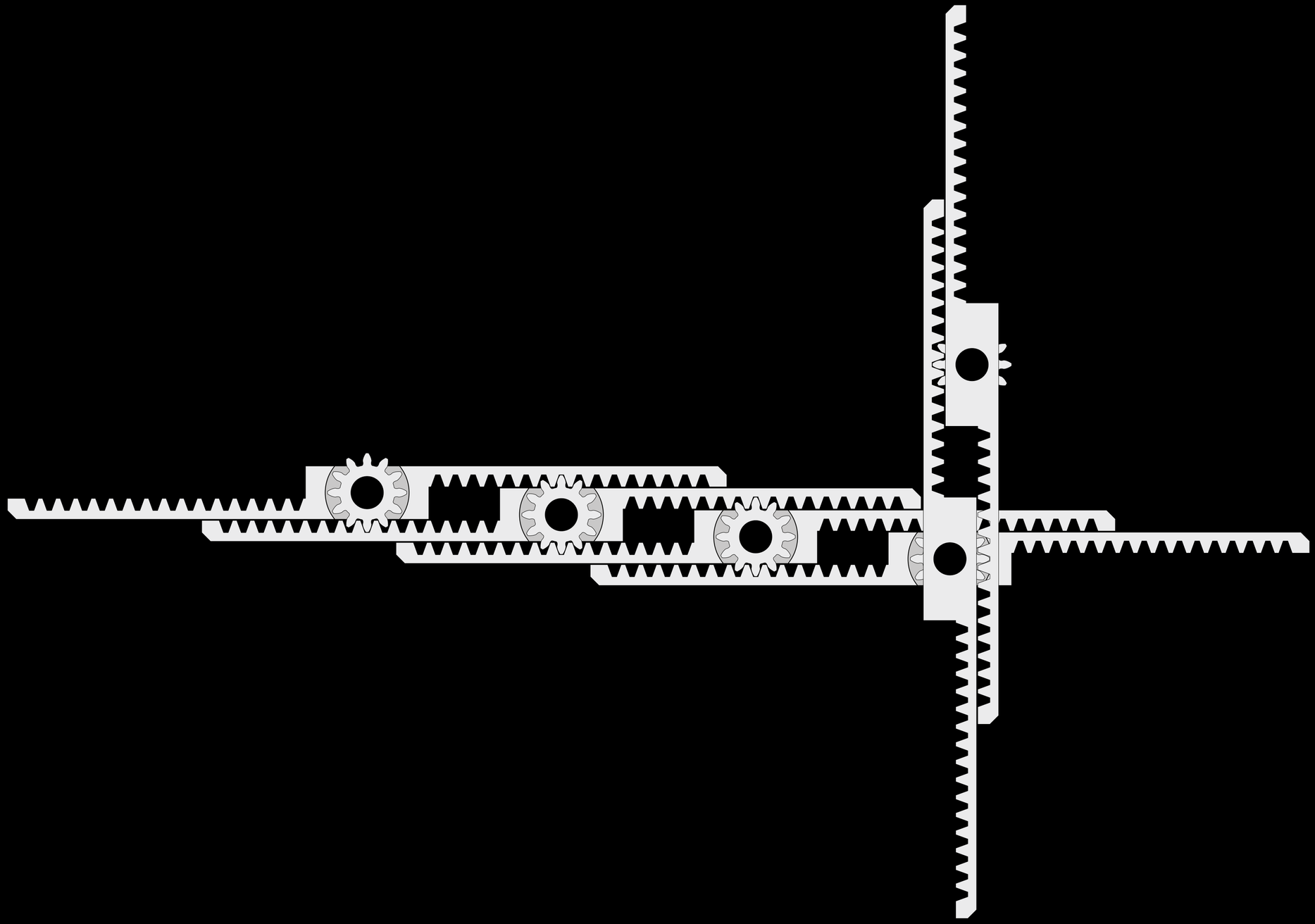


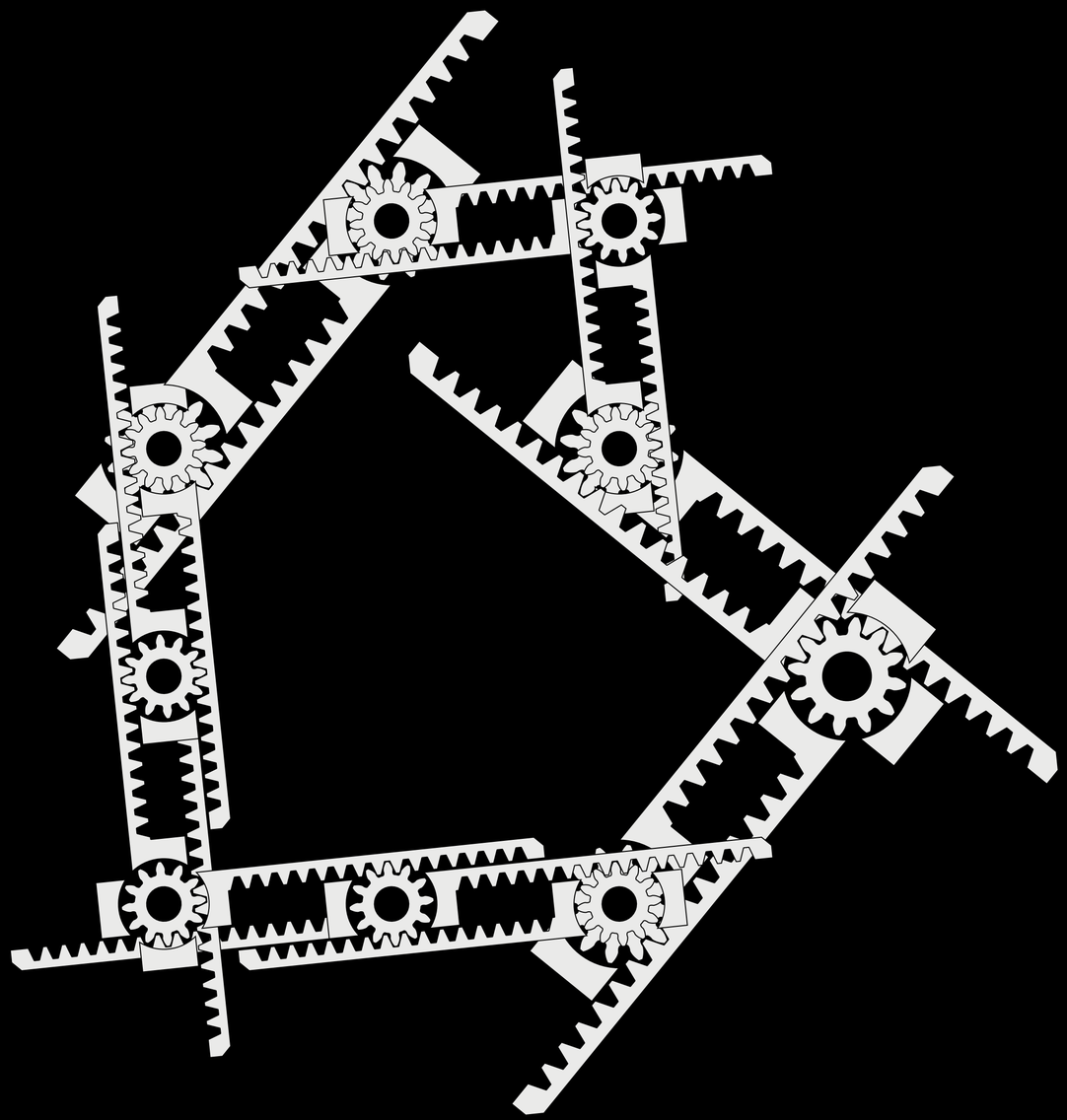

Tailspin mechanism by
Oskar van Deventer

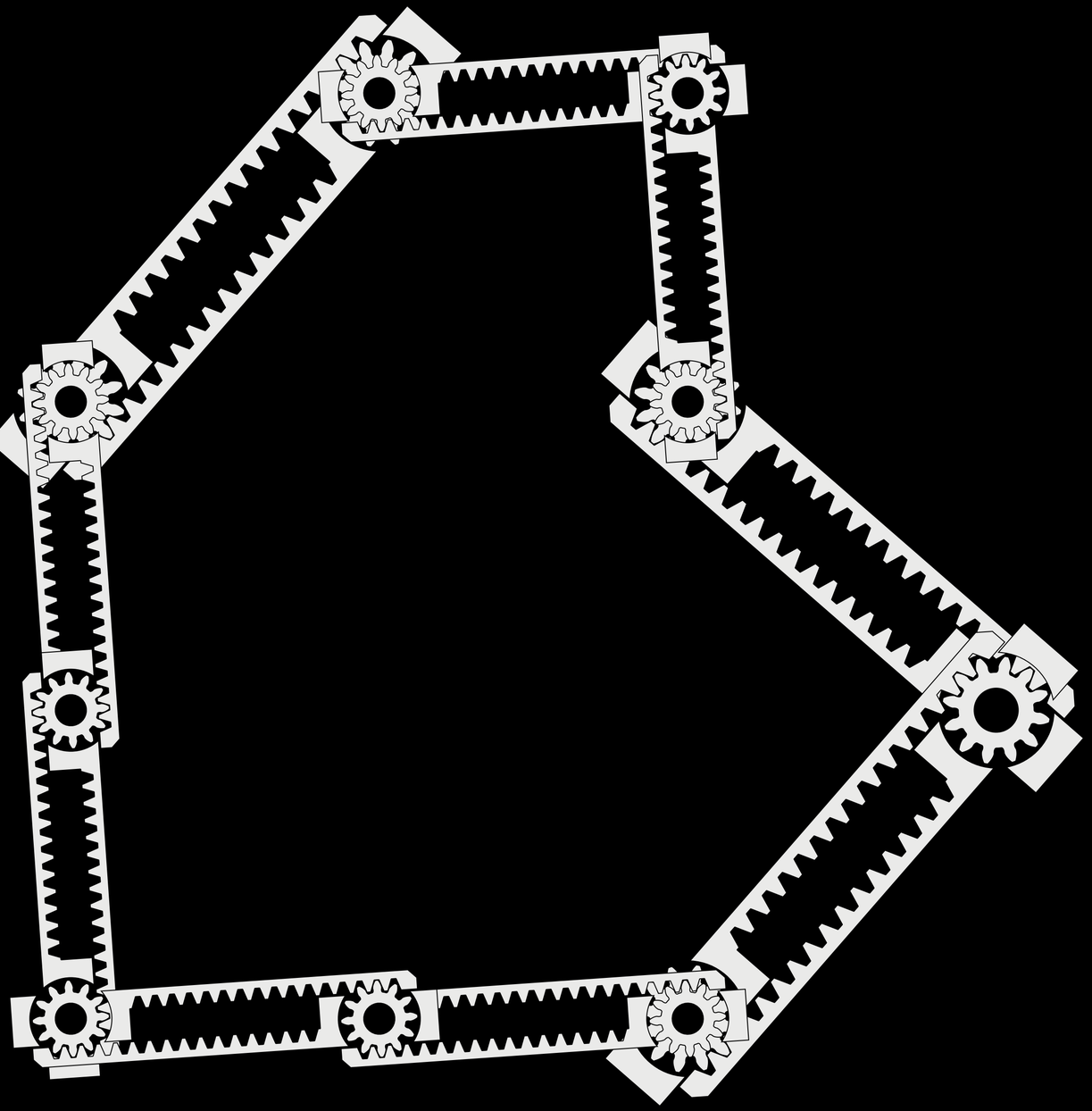


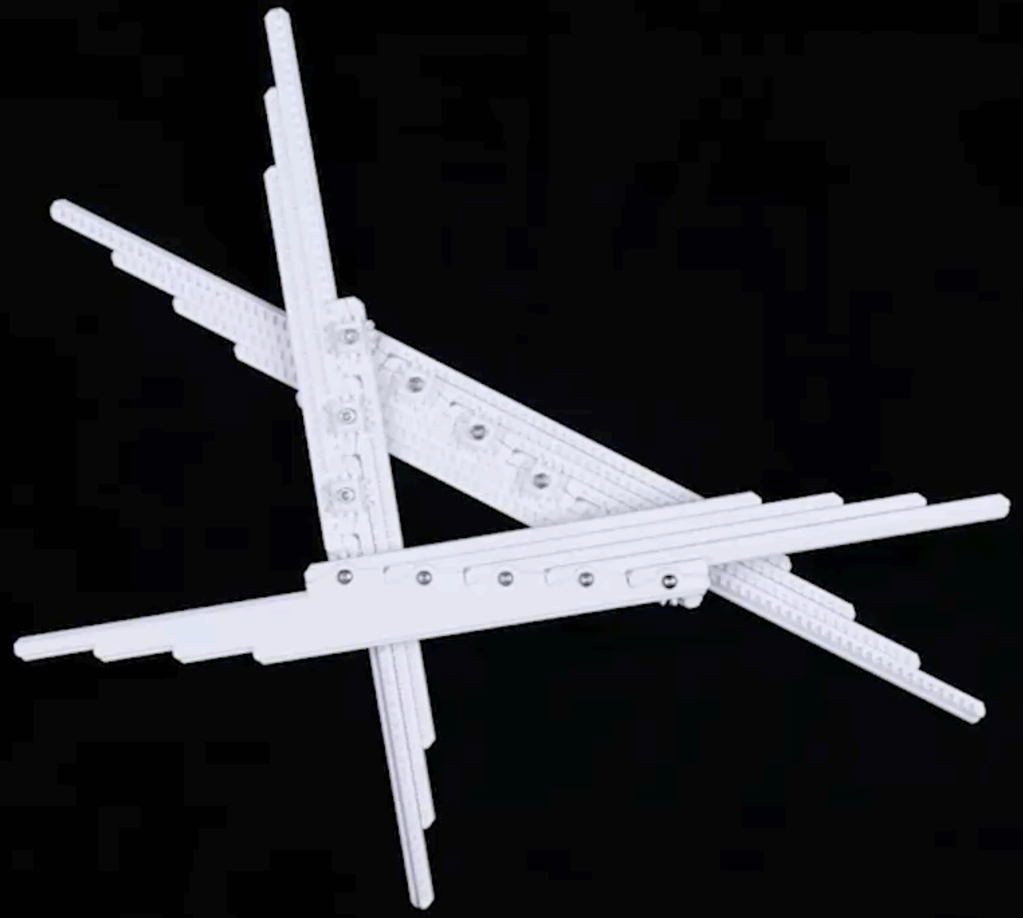

A
B
C
D

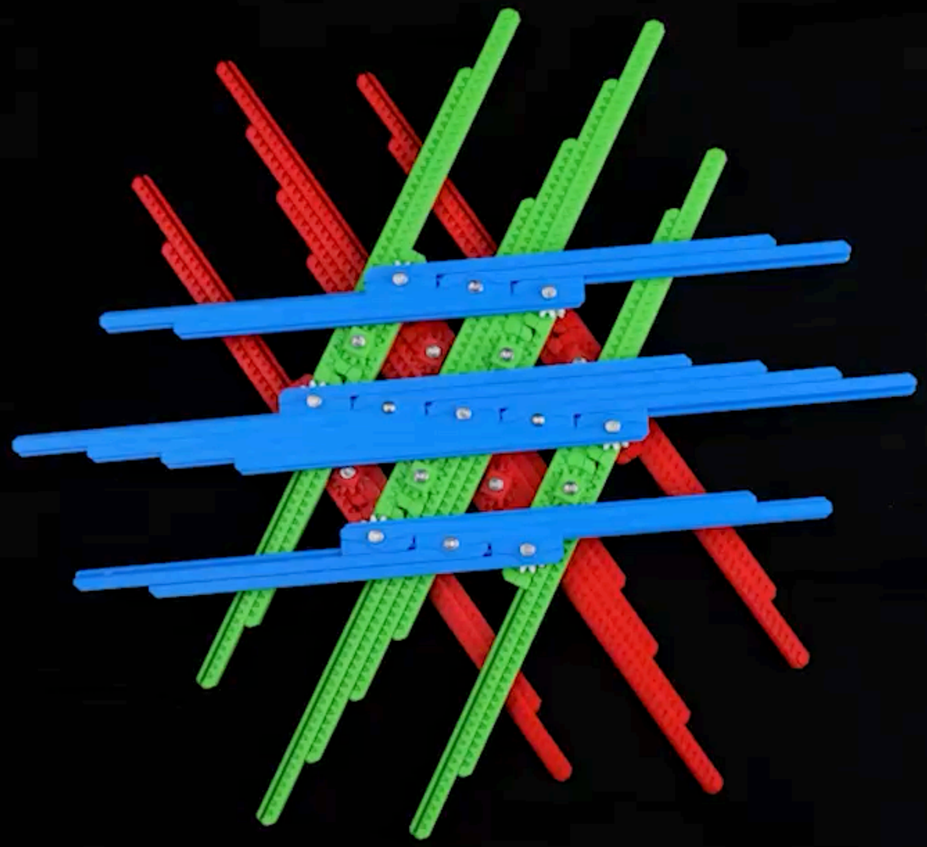

A
B
C
D



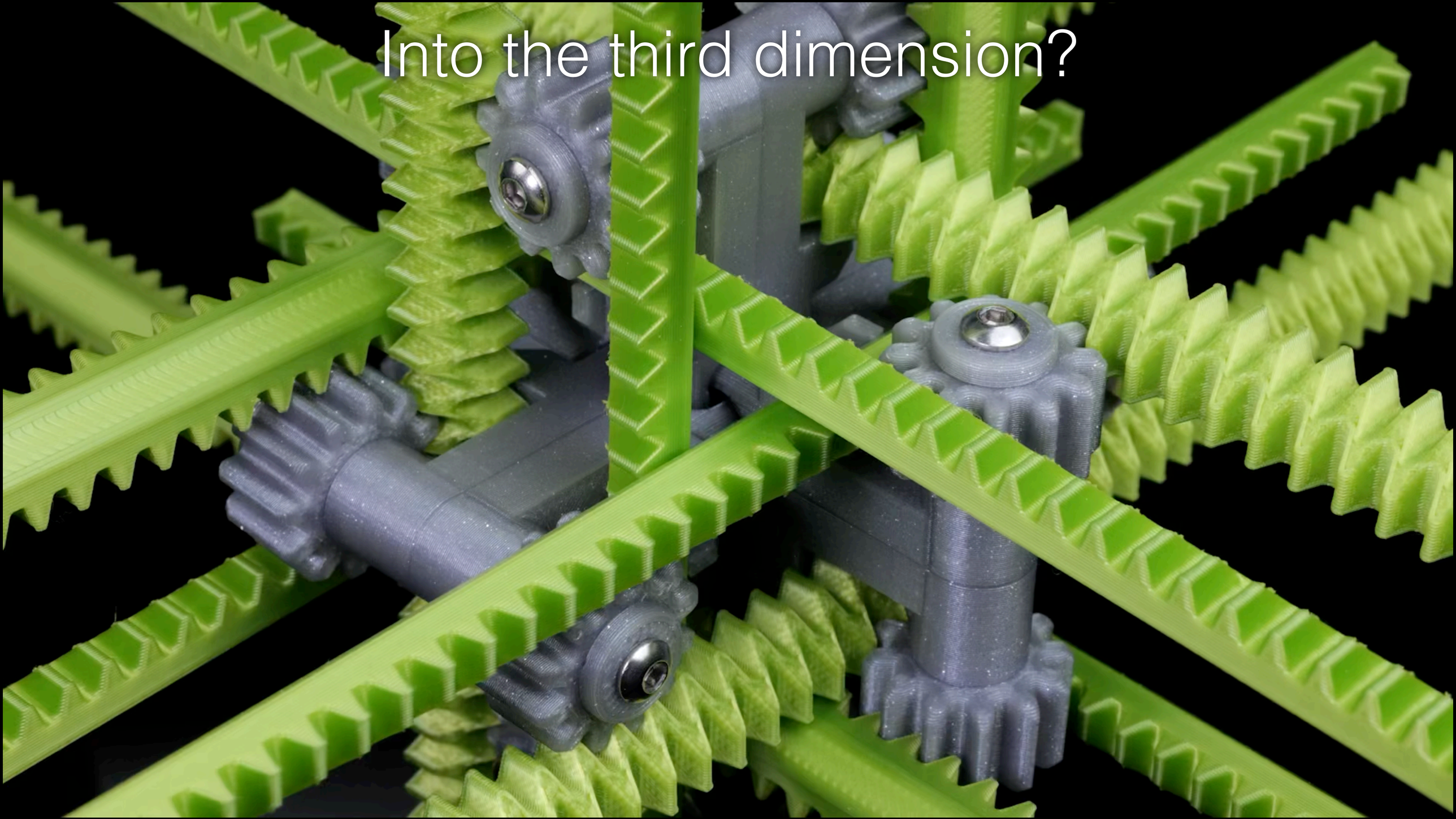


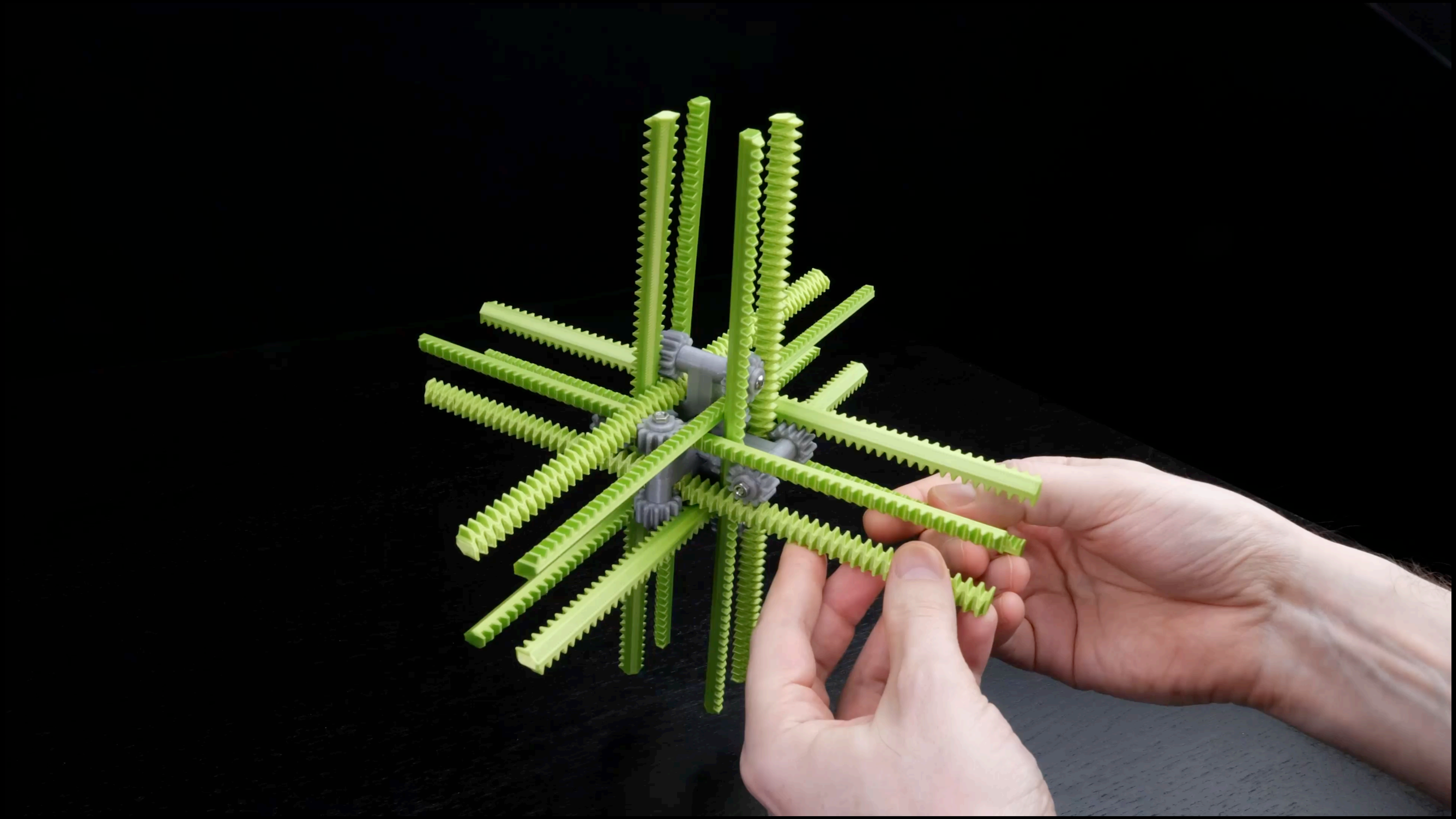


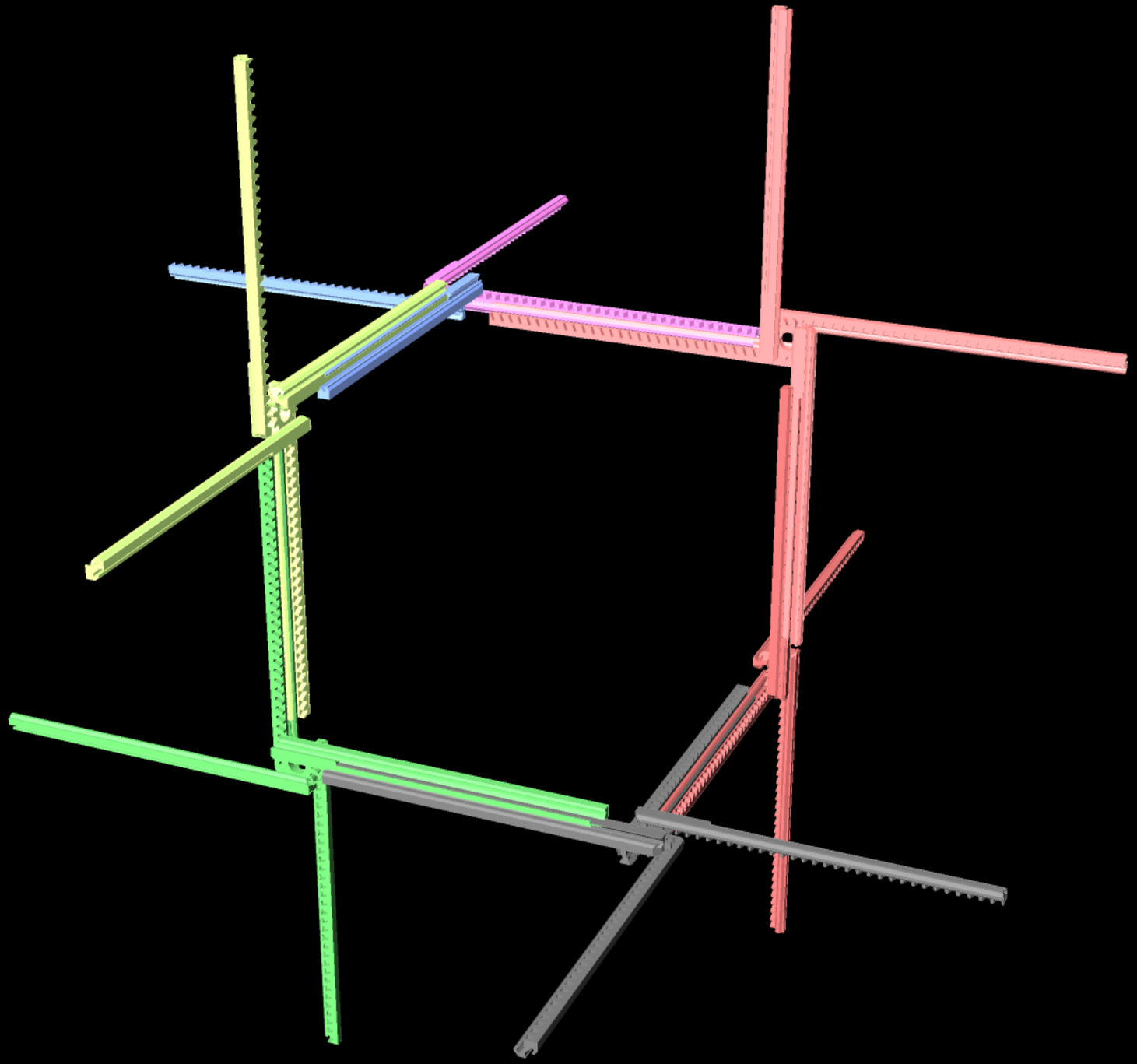


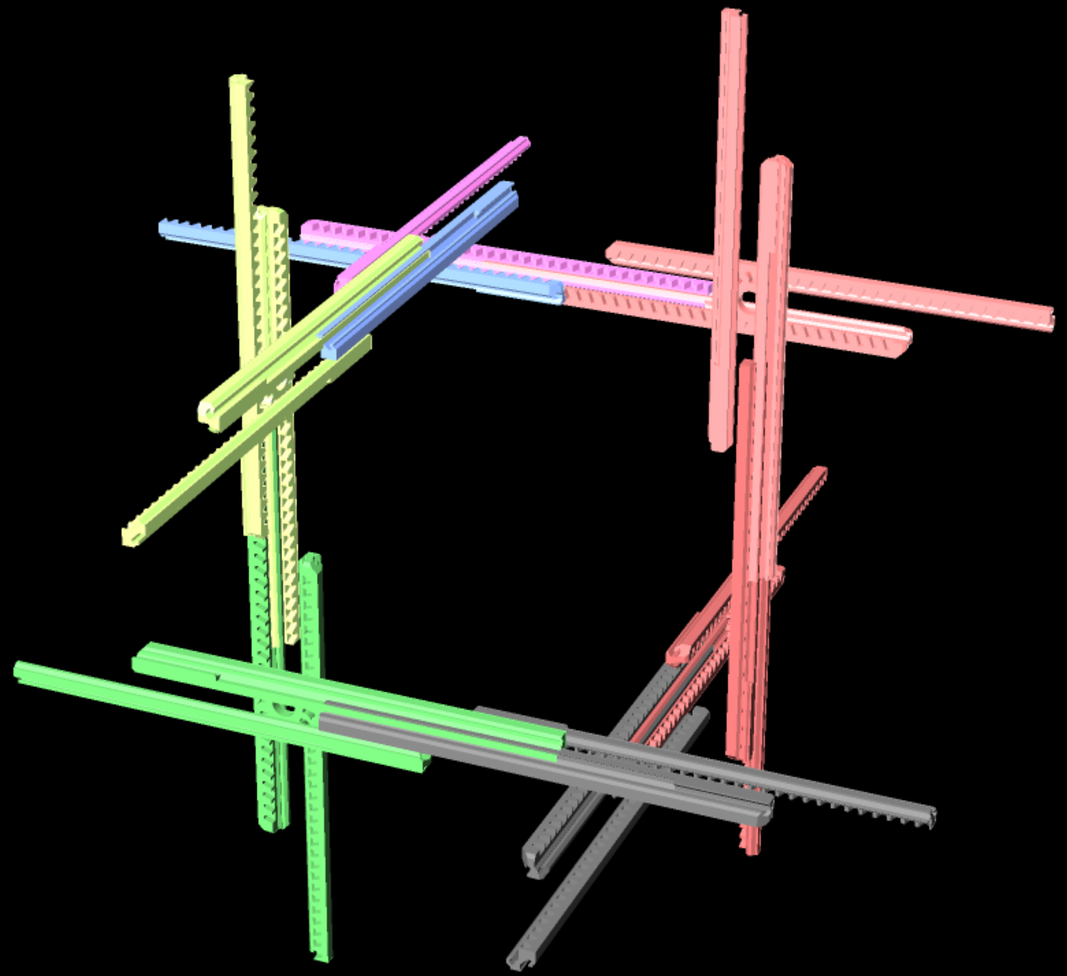


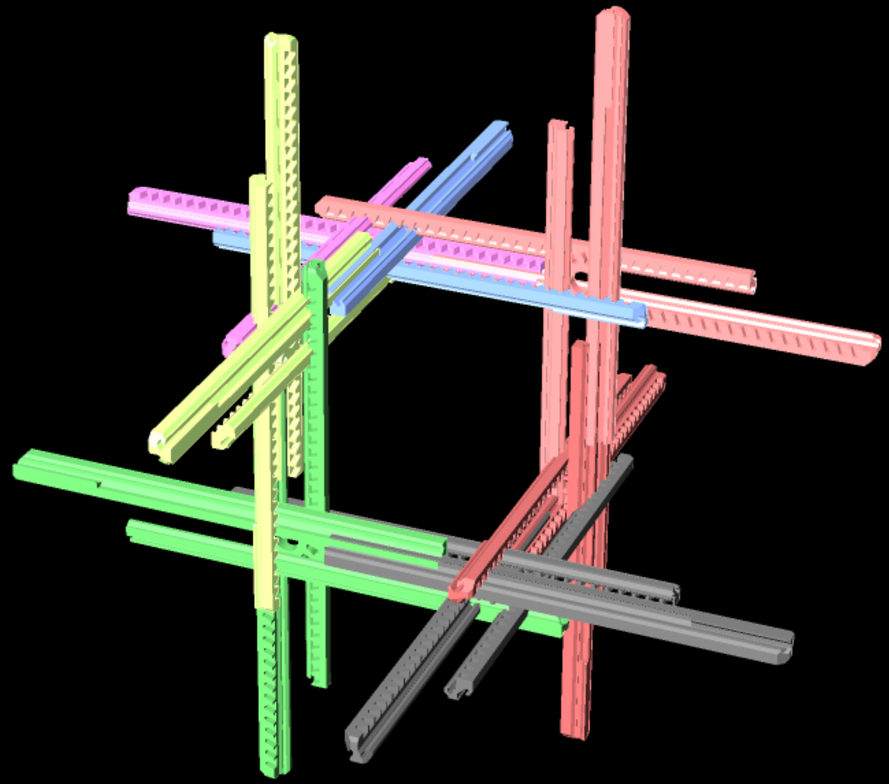
Into the third dimension?

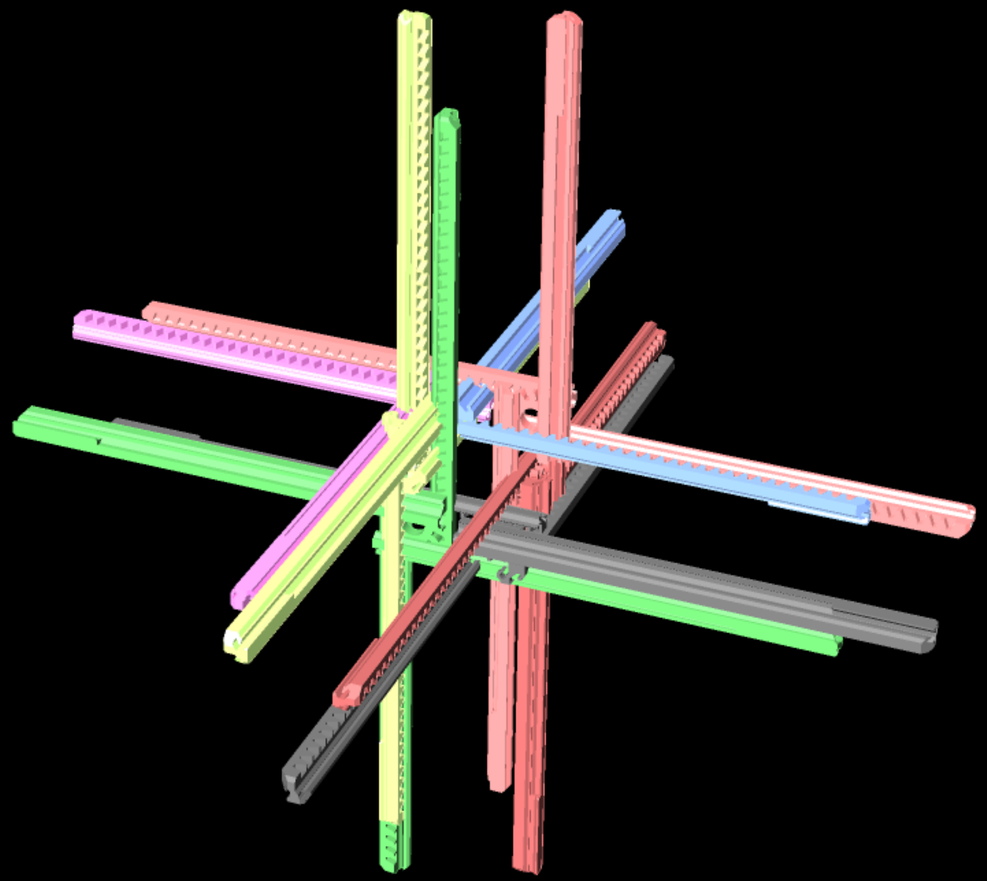


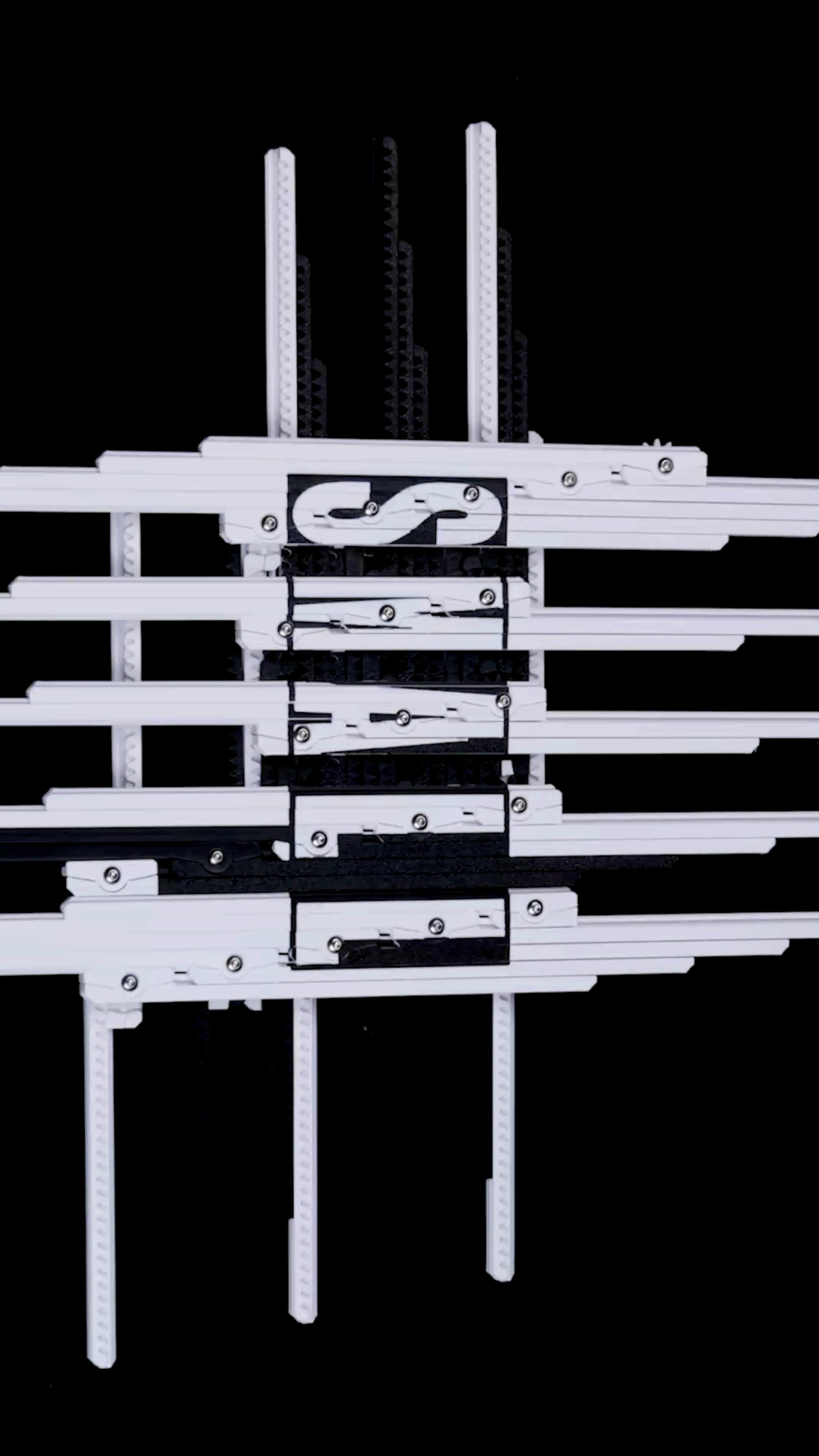












Thanks!