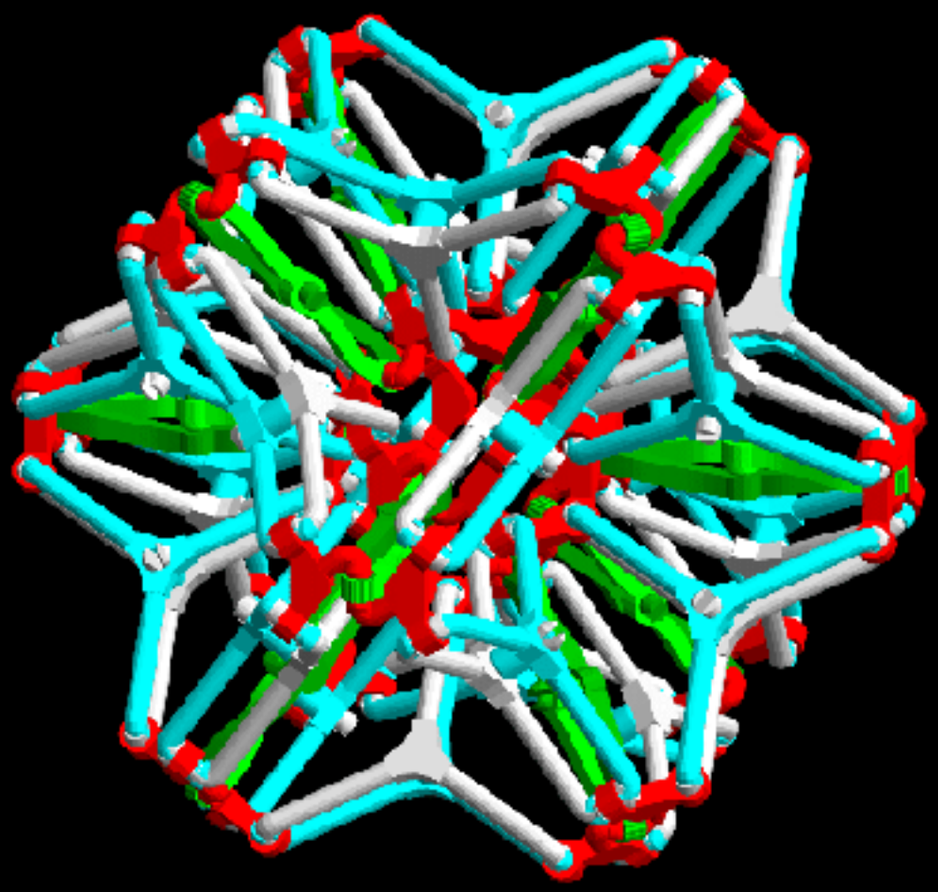
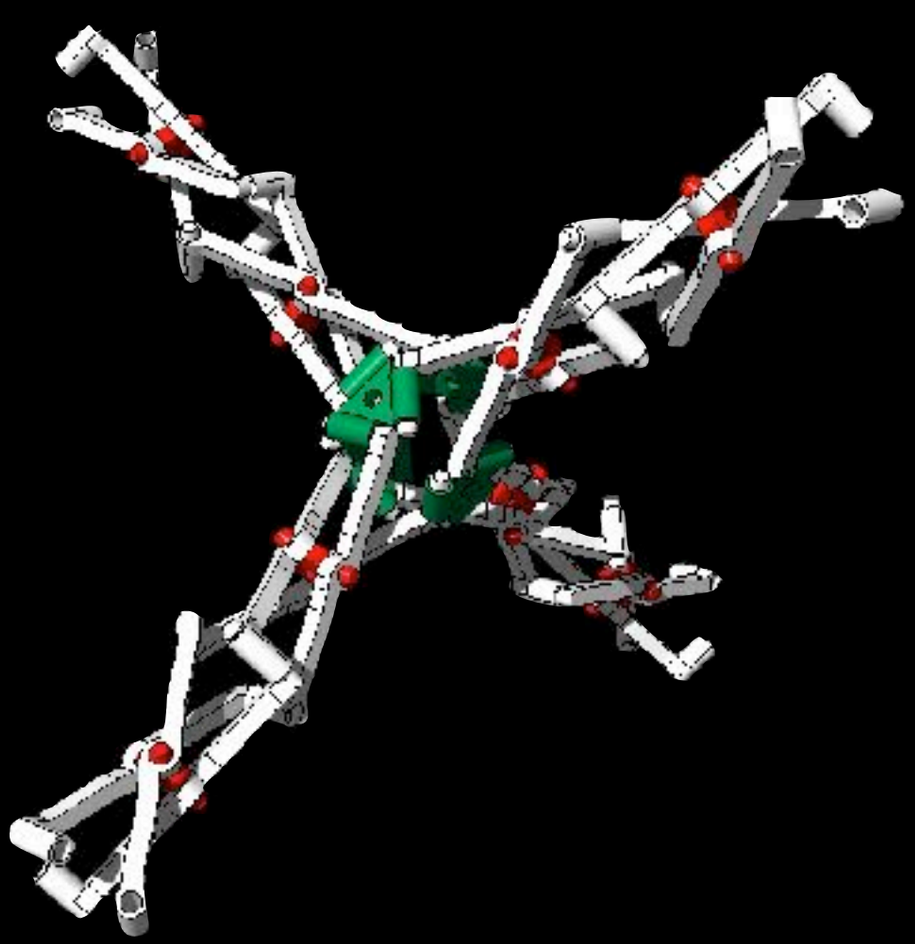
Design of hinged 3D auxetic mechanisms

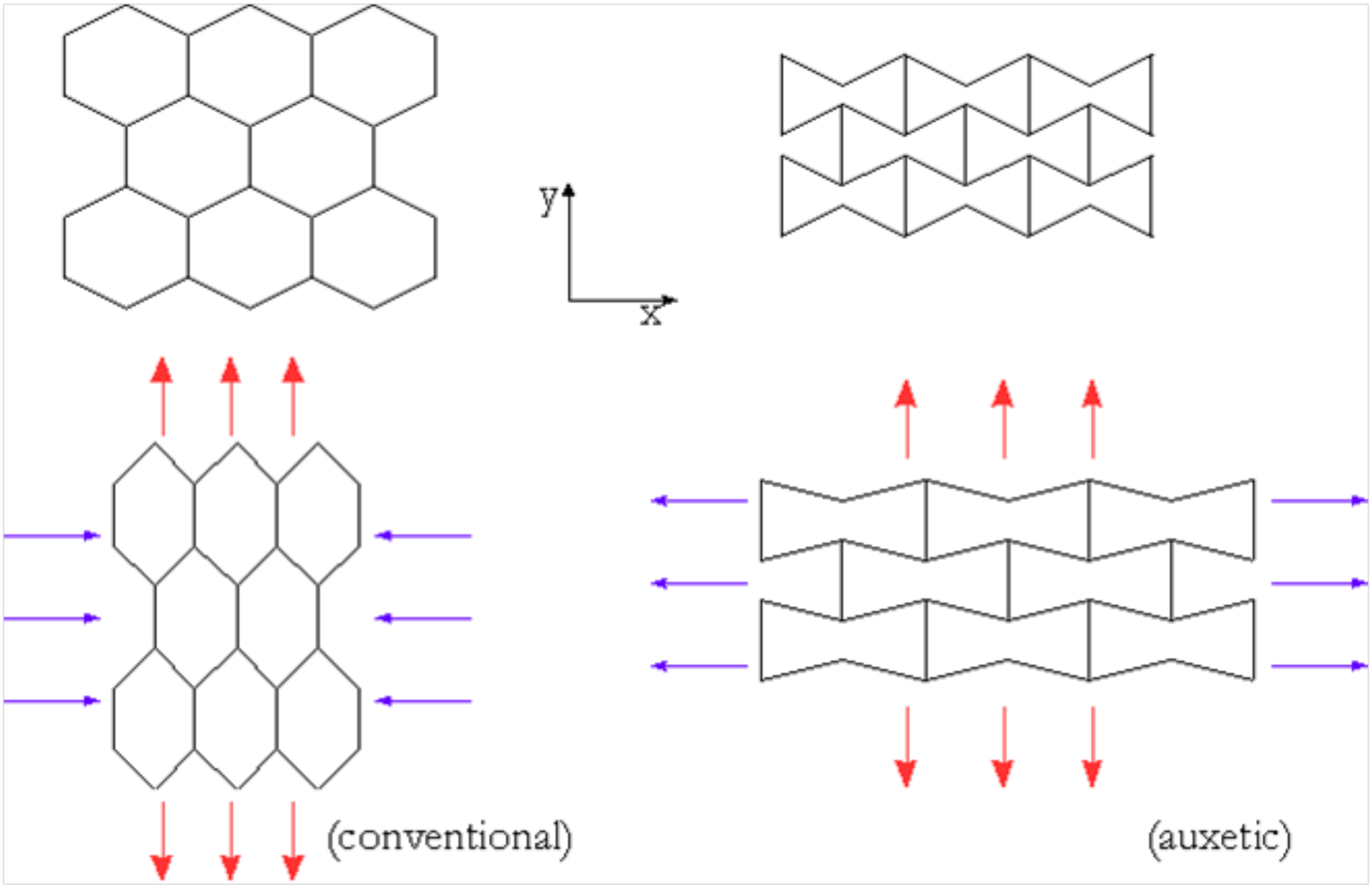
Elisabetta Matsumoto
Georgia Tech

Henry Segerman
Oklahoma State University



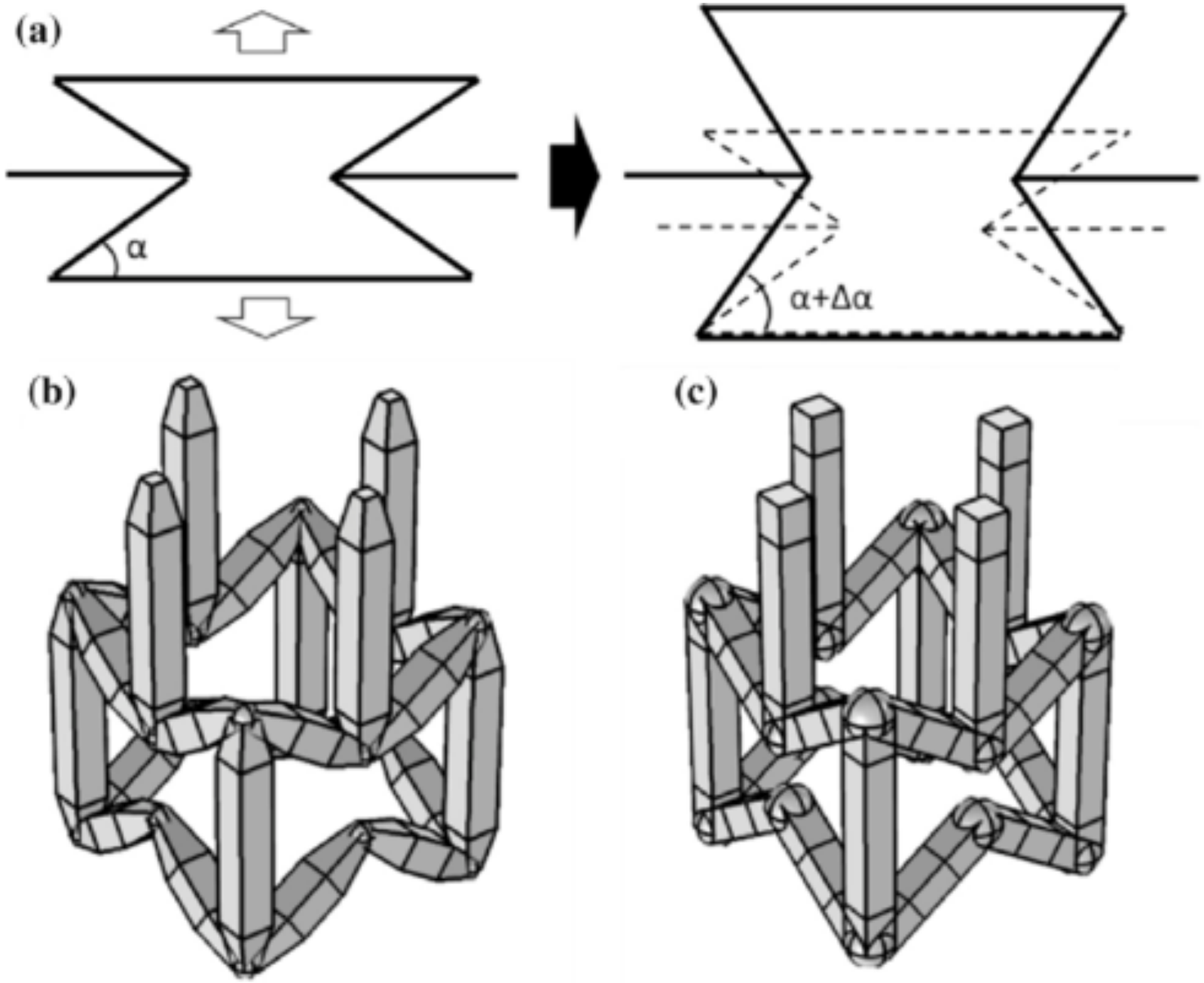


Auxetic mechanisms



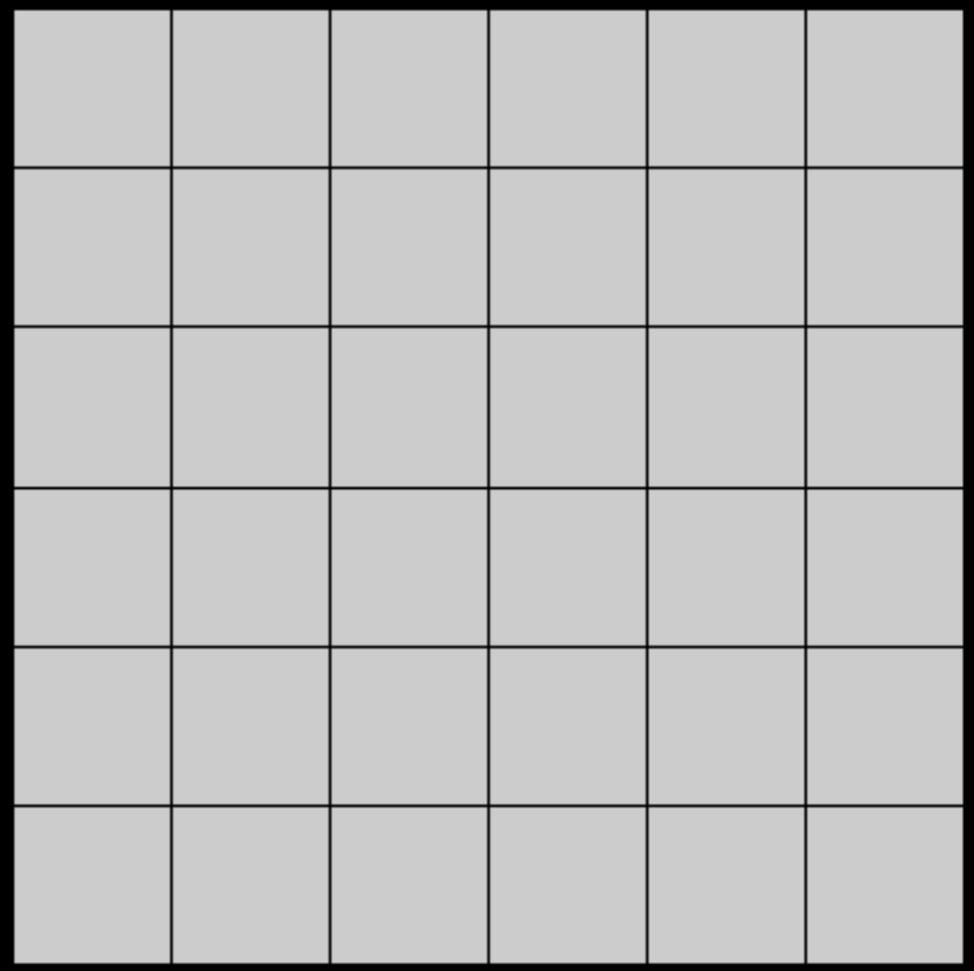
Source: https://smartstructures.wikispaces.com/Auxetic+Materials

Background: 3D auxetic mechanisms



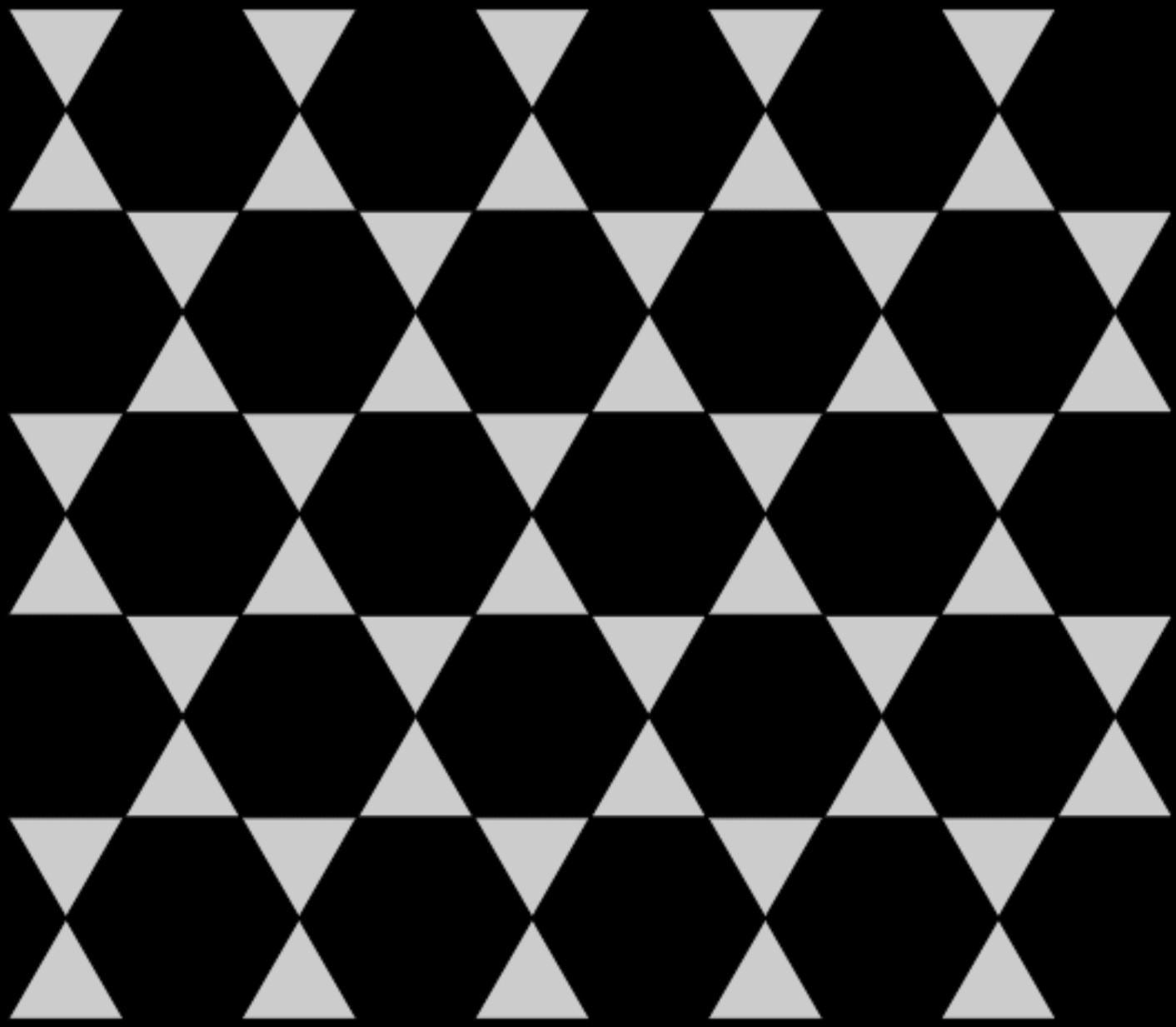
Source: Wang et al, Materials and Design, 2015
Designable dual-material auxetic metamaterials using three-dimensional printing

Background: 2D auxetic mechanisms



Diamond plate mechanism

Background: 2D auxetic mechanisms



Kagome mechanism

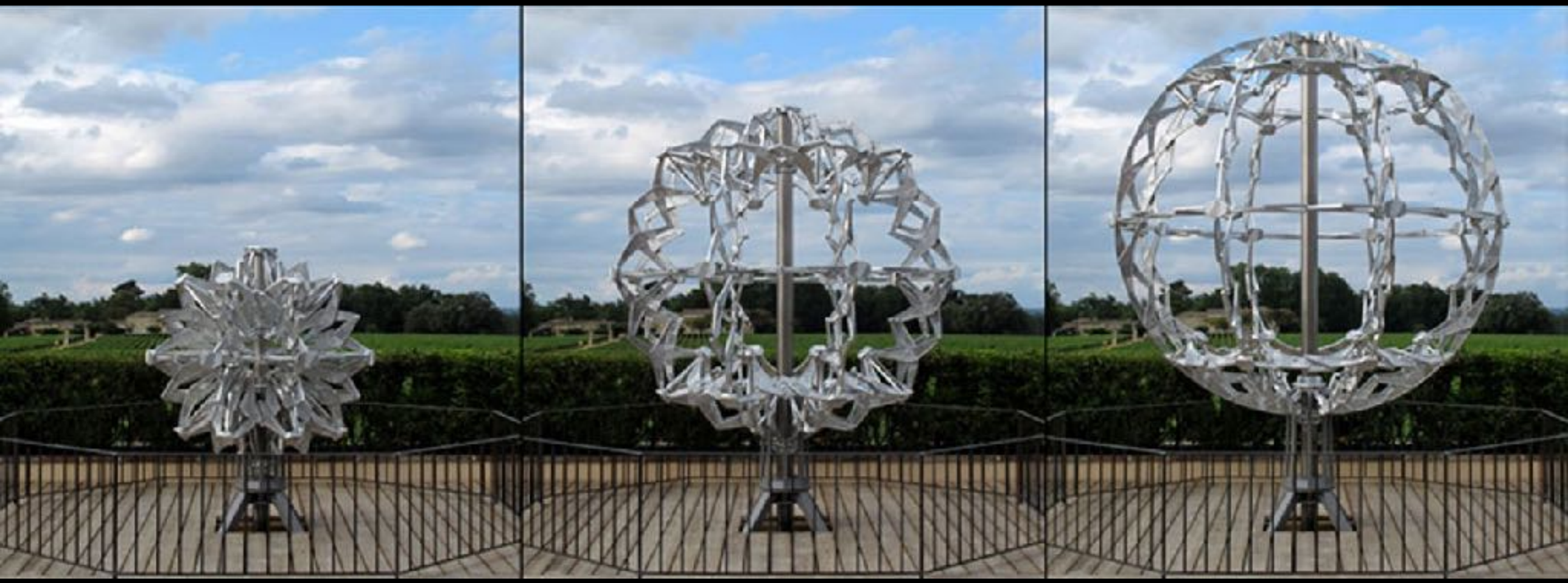
Background: 2D auxetic mechanisms

Jitterbug Atom, by Buckminster Fuller

3D auxetic mechanisms

Jitterbox, by Taneli Luotoniemi

Background: 2D auxetic mechanisms



Source: http://now.lincoln.com/movement-by-design-an-interview-with-chuck-hoberman/

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

Questions

A. How can we make a regular (planar) tiling auxetic?

B. How can we make an arbitrary (planar) graph auxetic?

C. Can we answer these questions in 3D?

D. Are there constraints on the possible values of the Poisson ratio (tensor)?

E. Are there constraints on the possible values of the expansion factor?

F. Can we achieve these things in real-life?

Hoberman's polygon mechanism

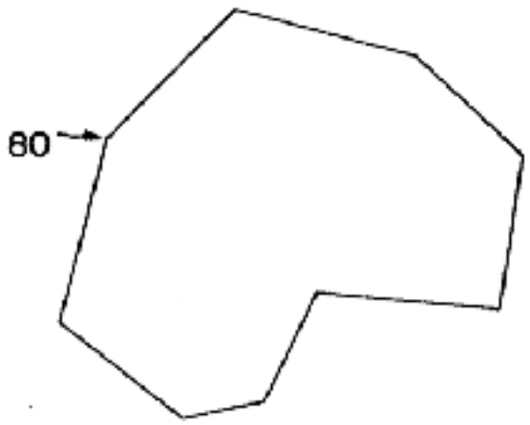


FIG.4

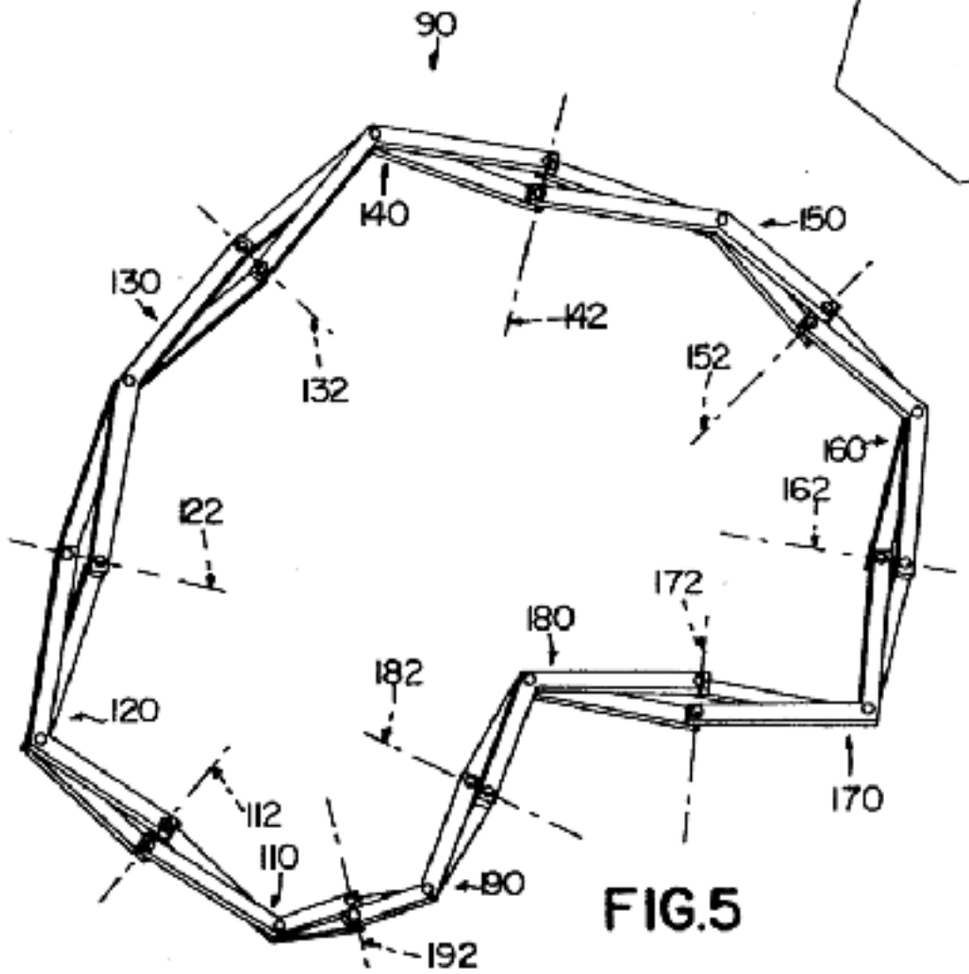


FIG.5

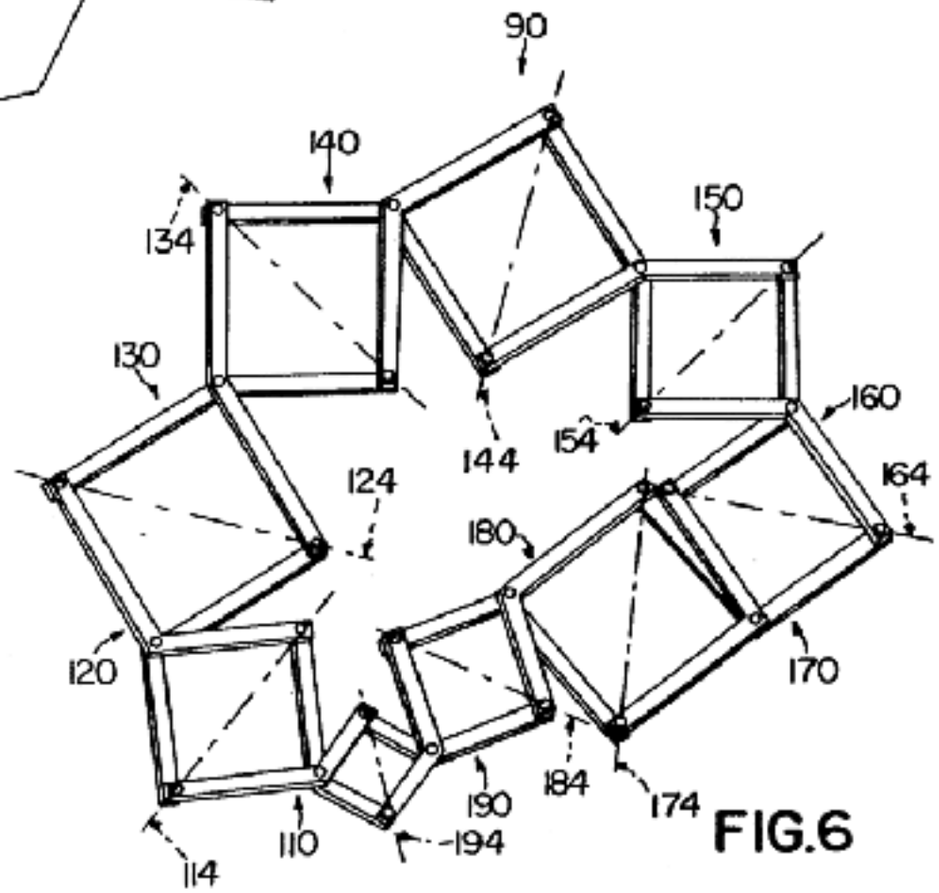
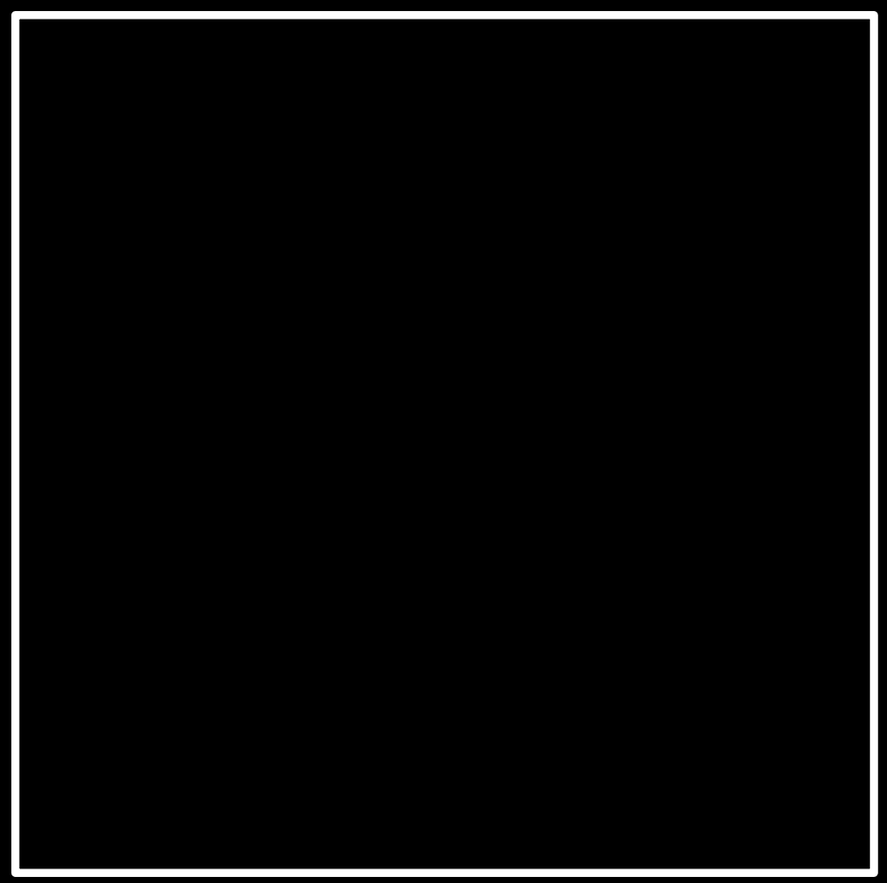
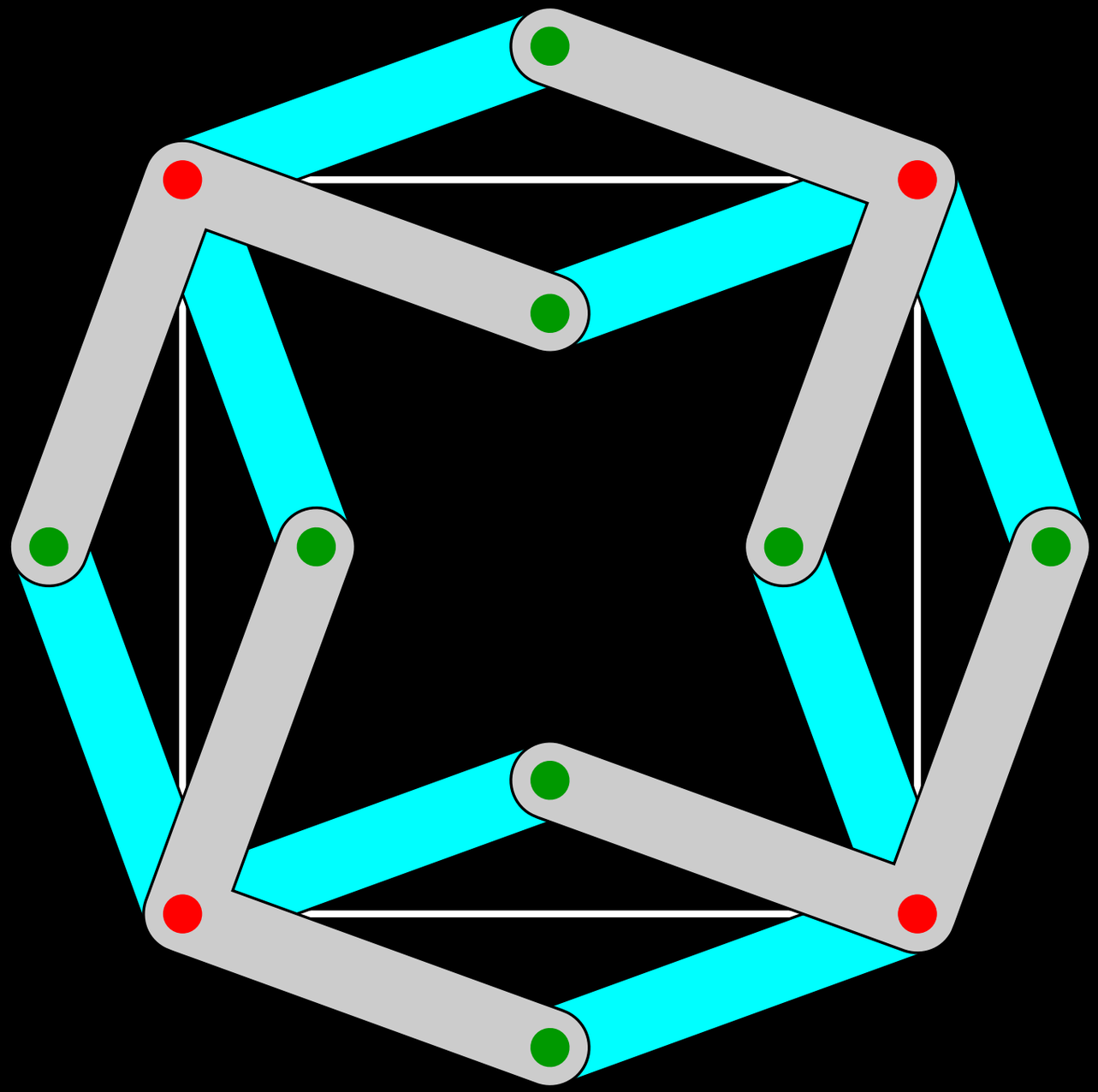
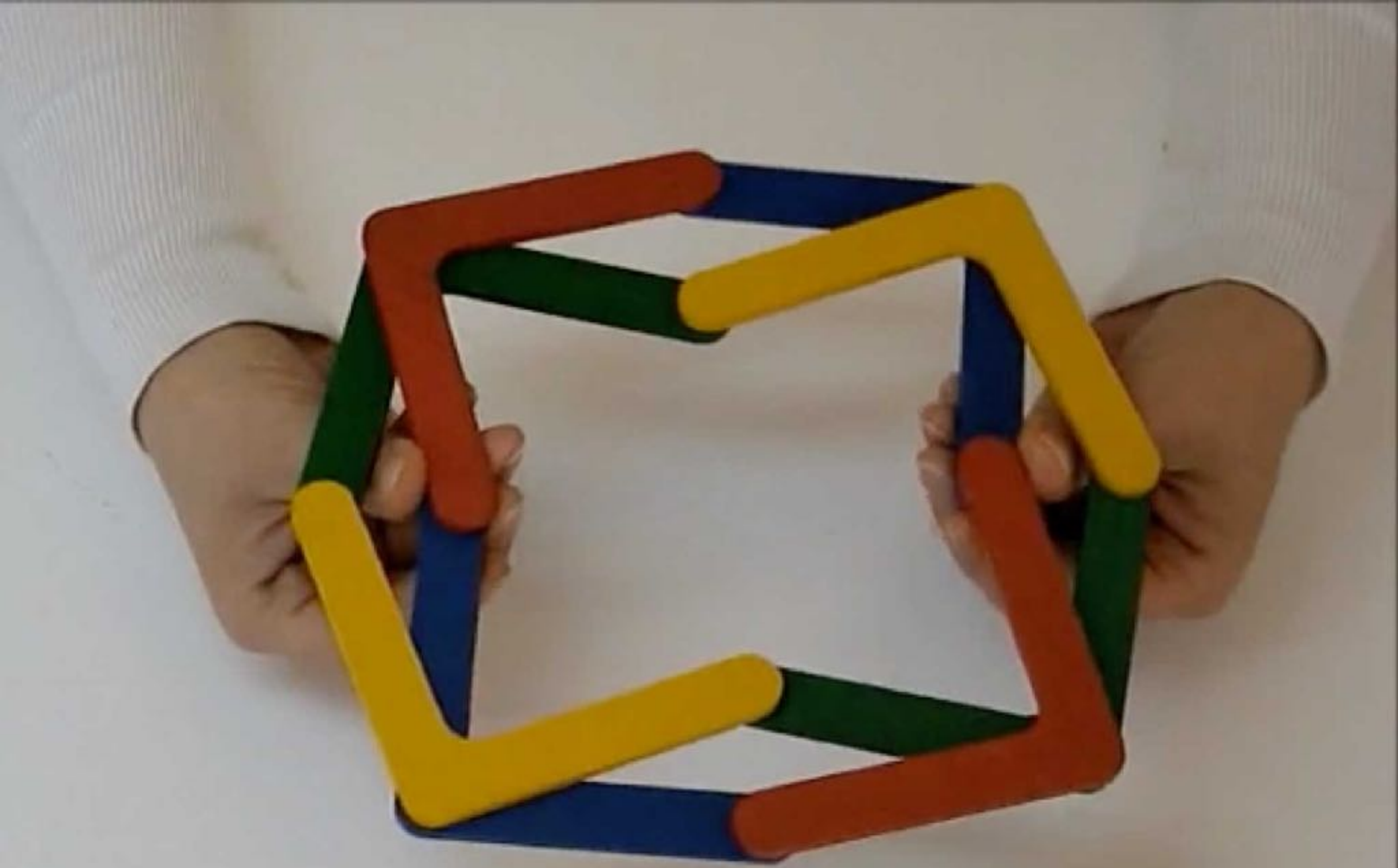


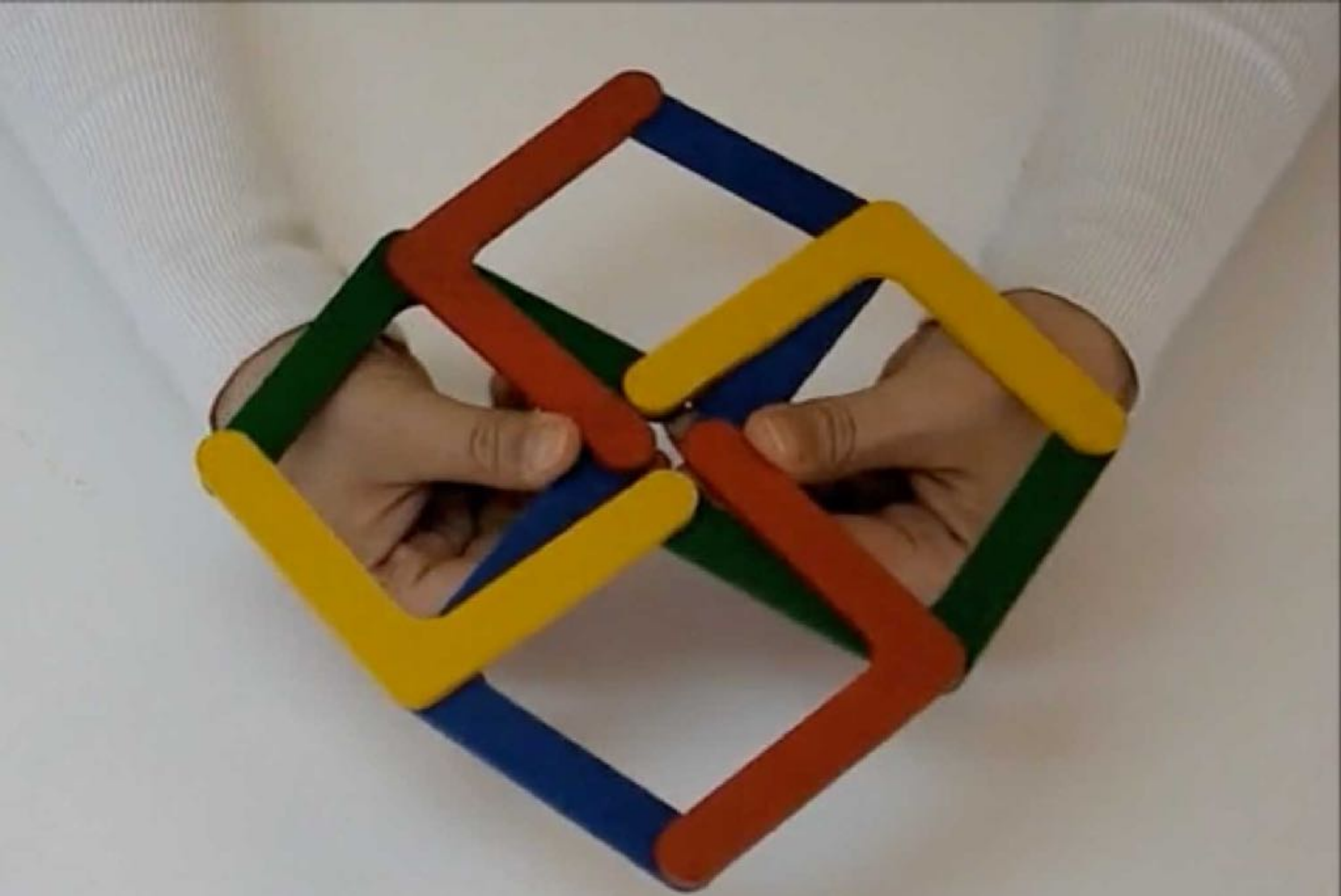
FIG.6



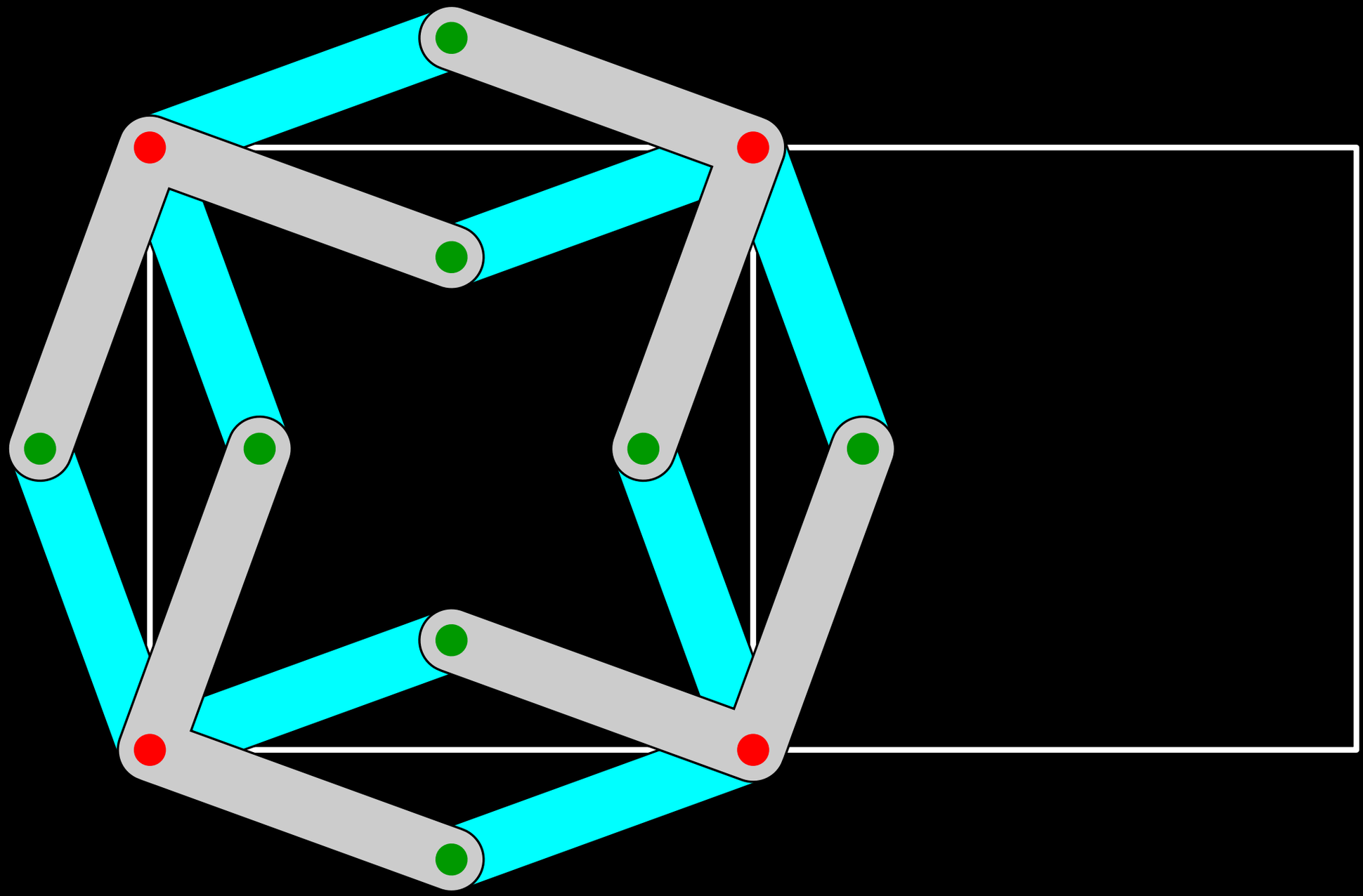


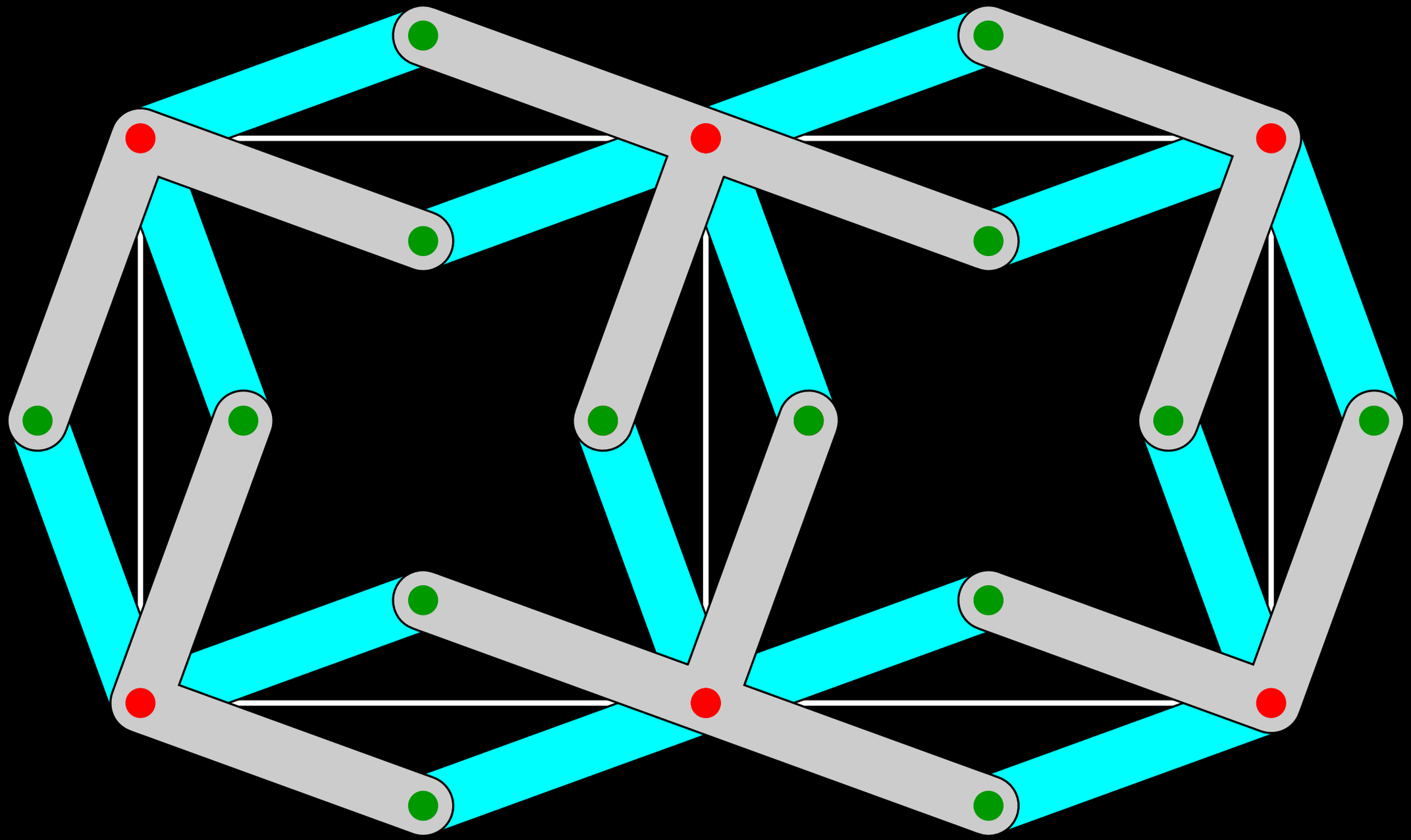


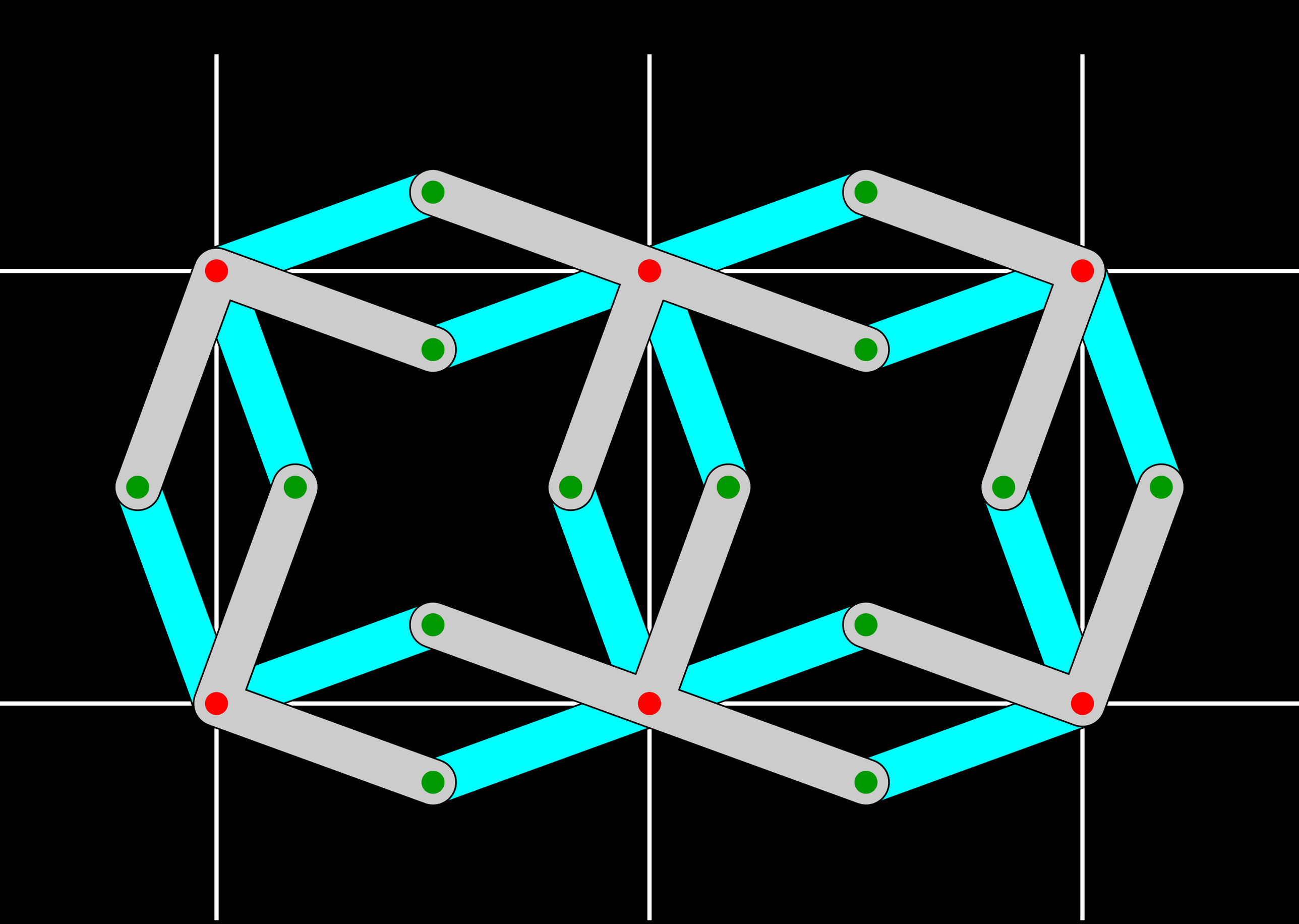
Octopieces, by Negar Kalantar

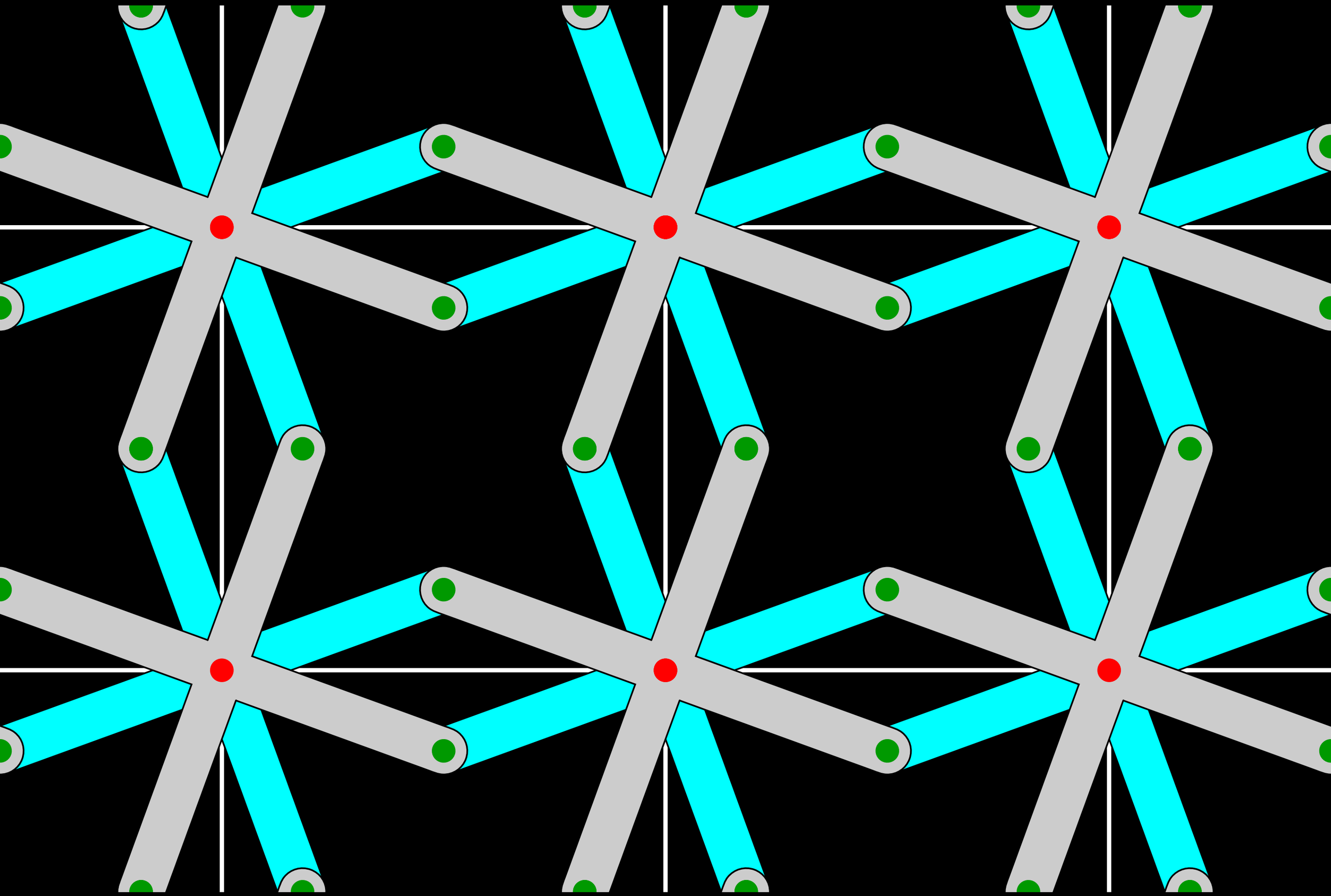


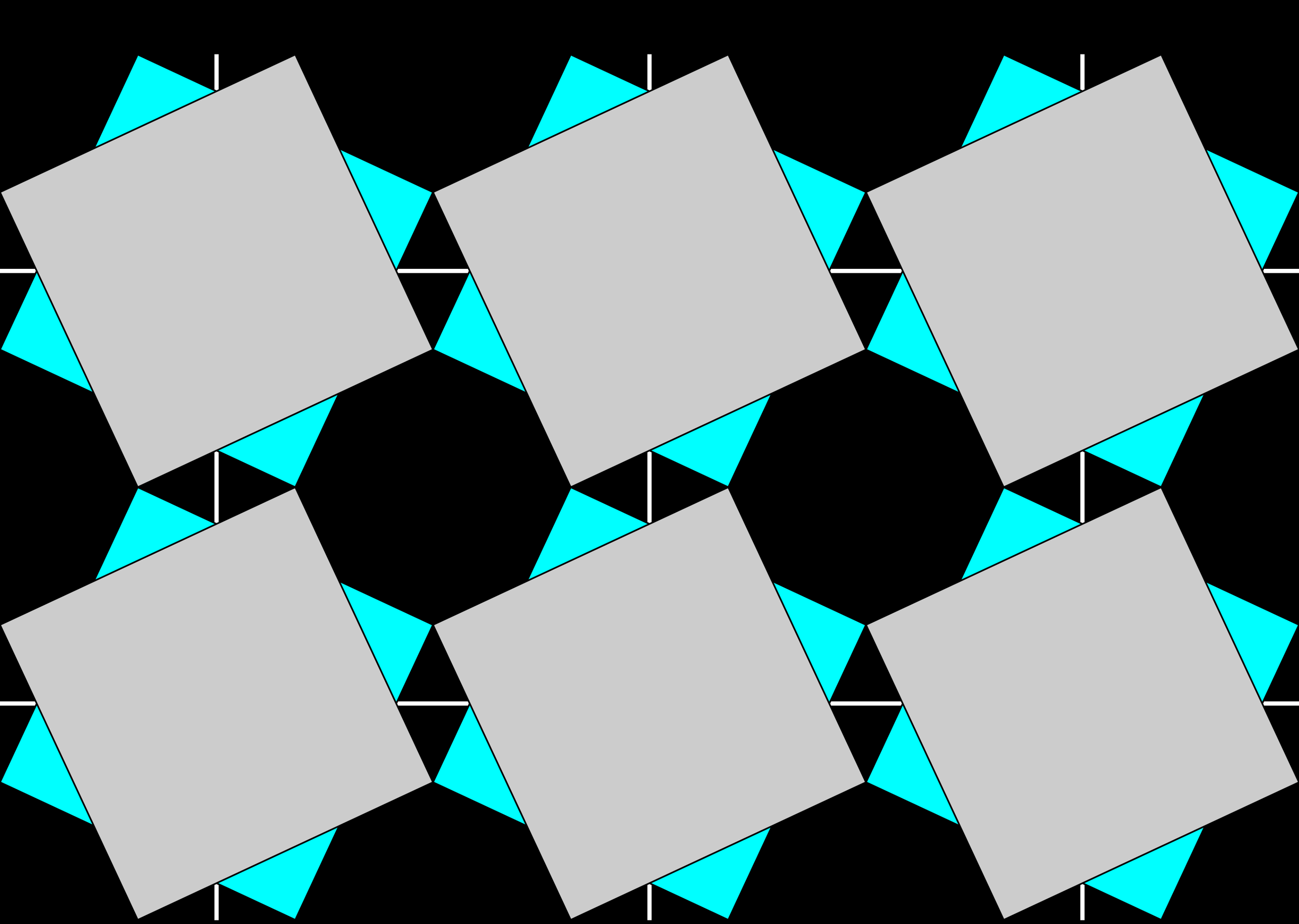
Octopieces, by Negar Kalantar

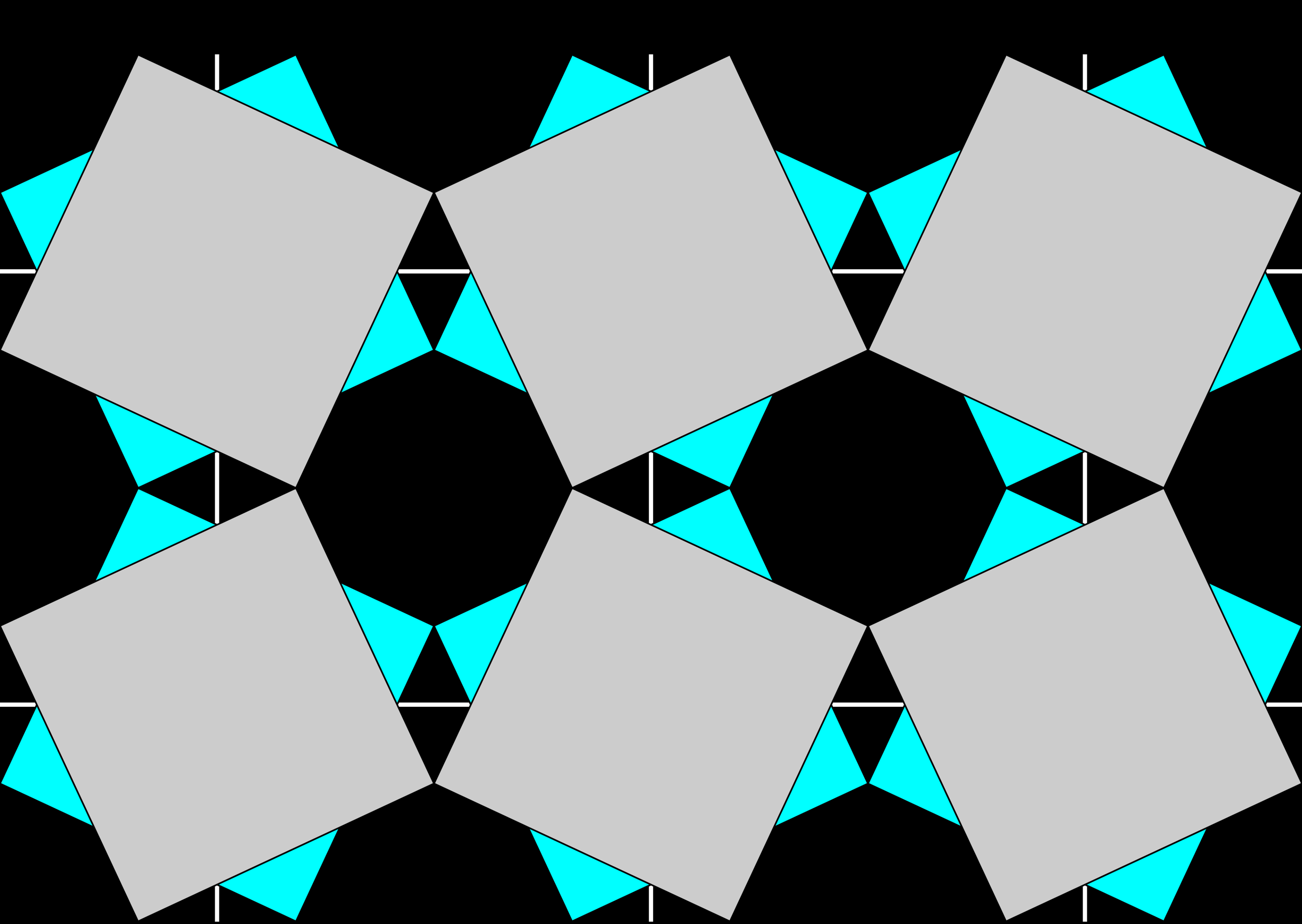








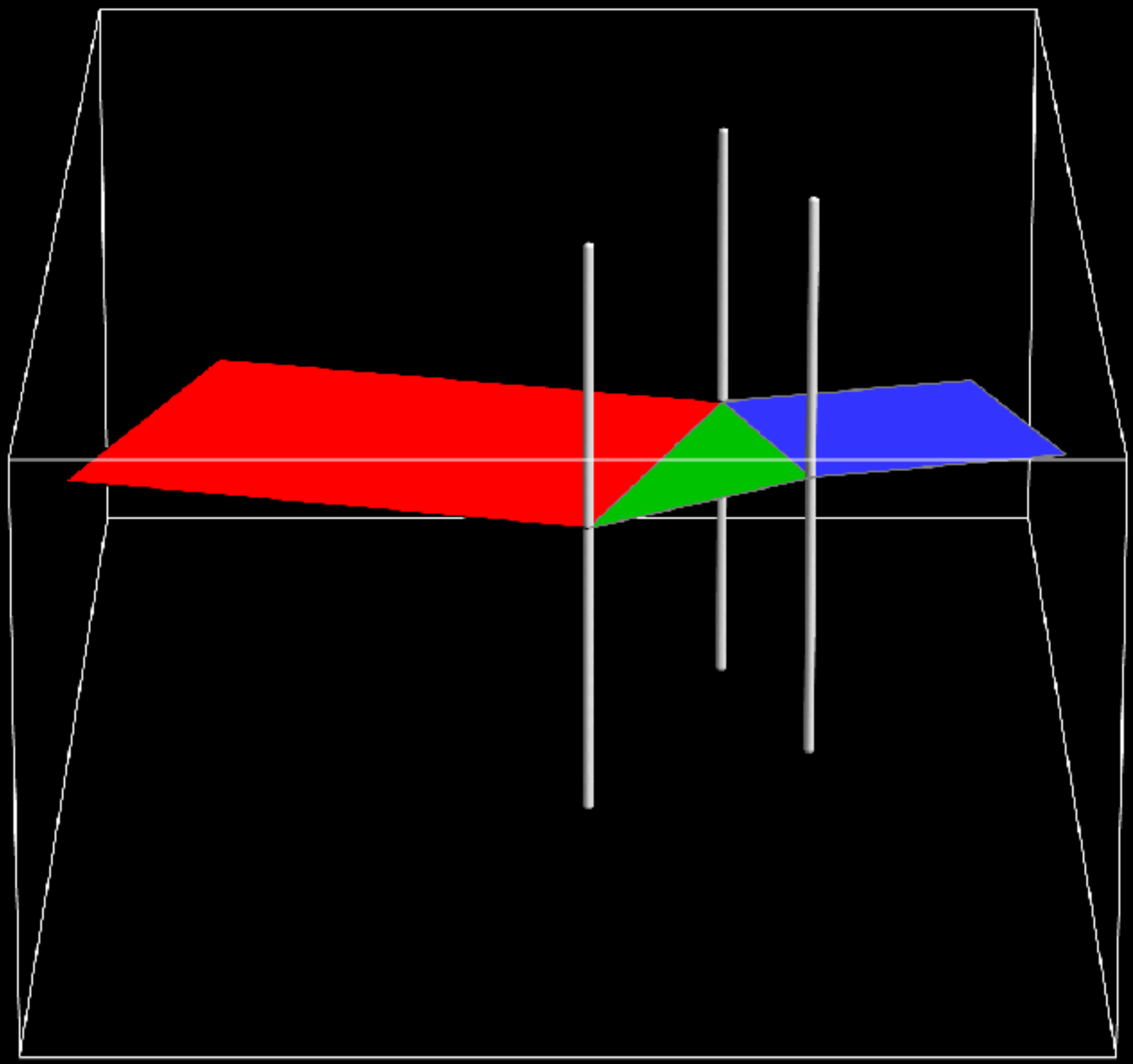




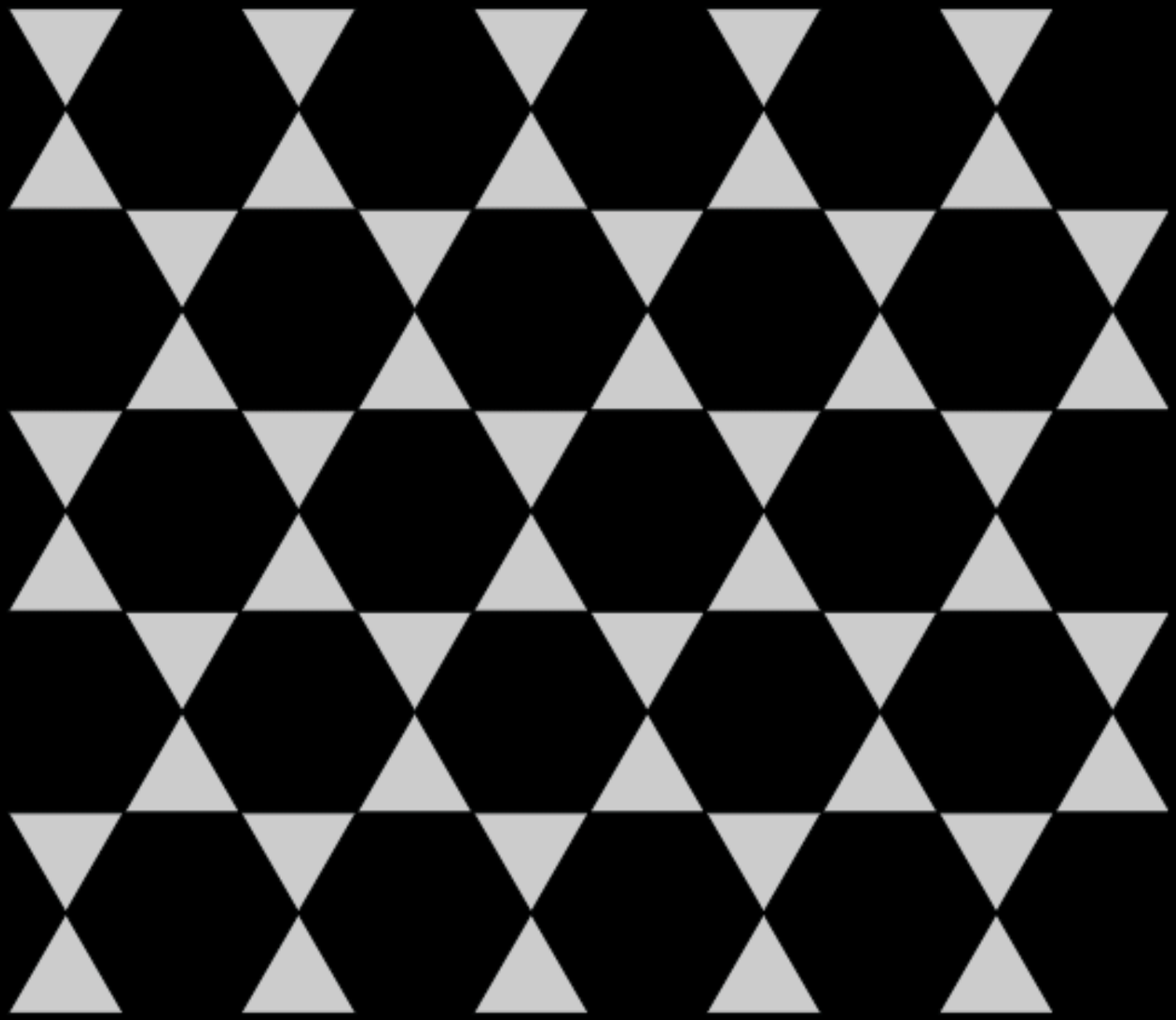
New ideas: from 2D to 3D

1. The one degree of freedom hexagon
2. Counterrotating elements
3. Branched scissor linkages
4. Additional linearly dependent supports

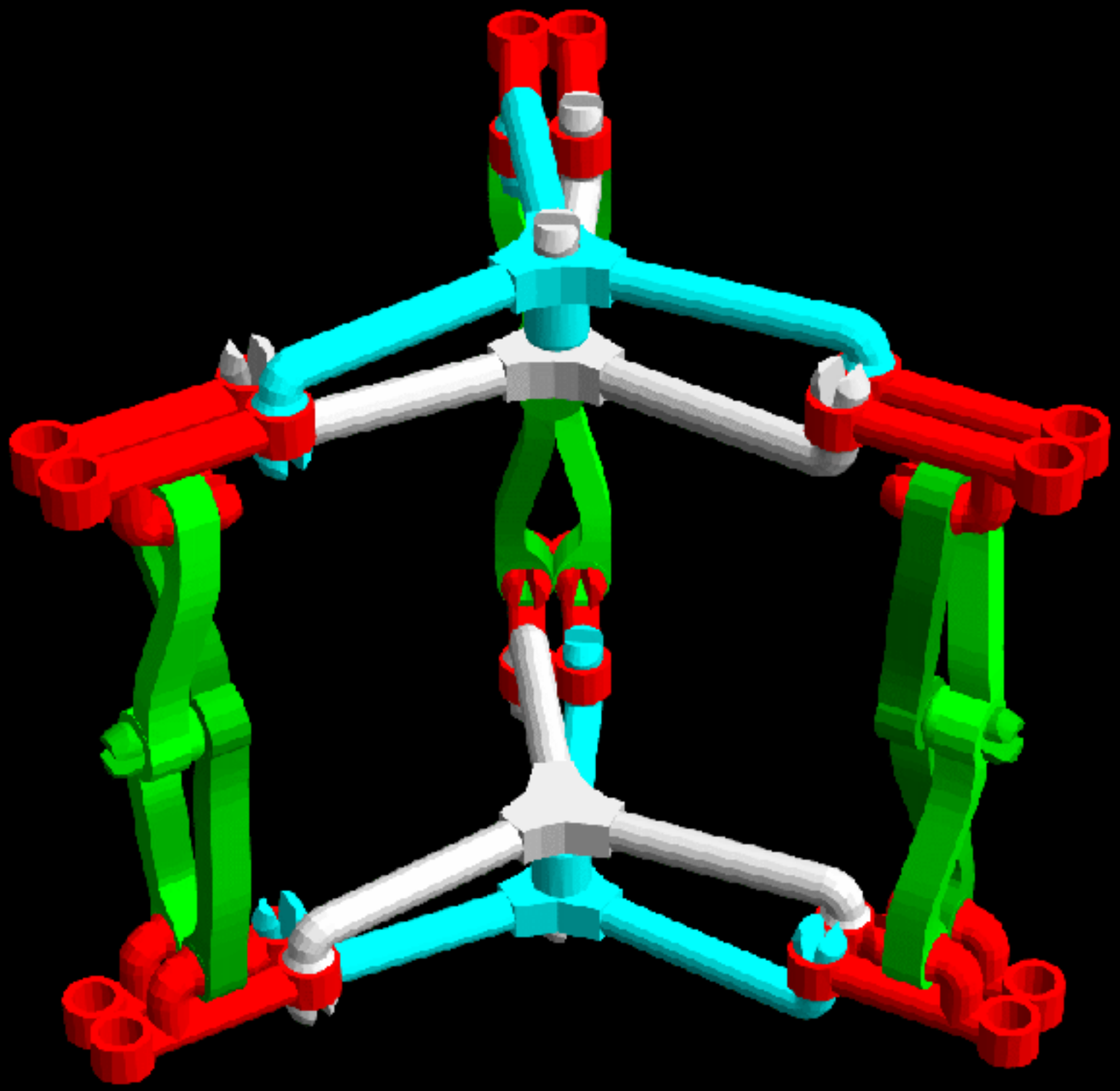
1. One degree of freedom hexagon



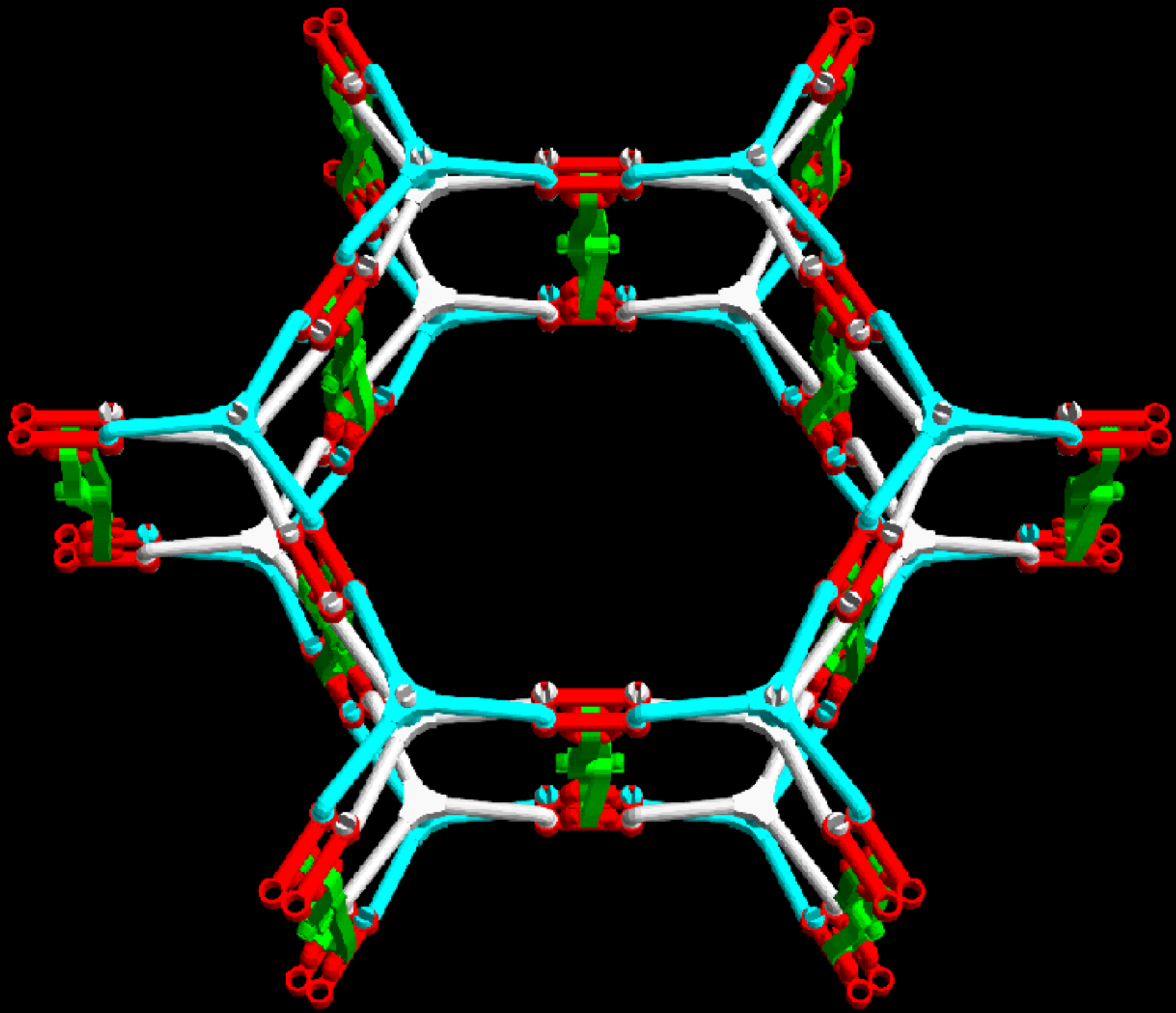
2. Counterrotating kagome



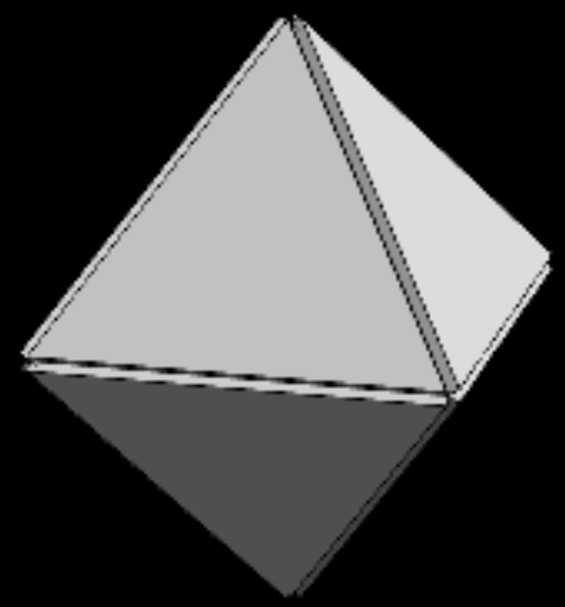
Layered kagome



Layered kagome



Counterrotating jitterbug



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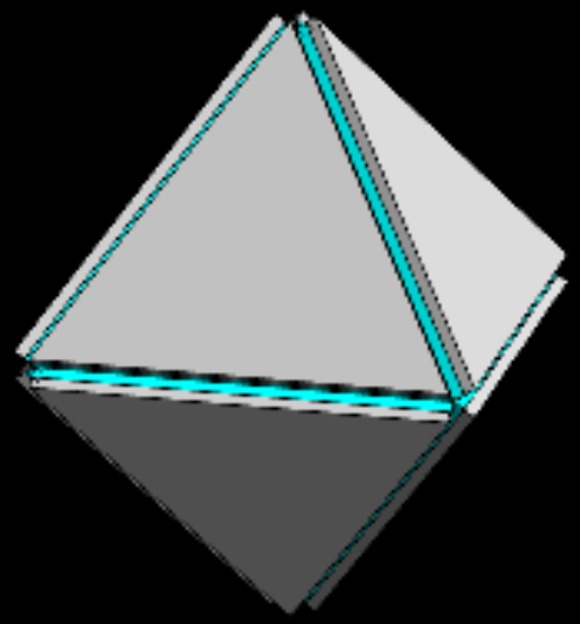
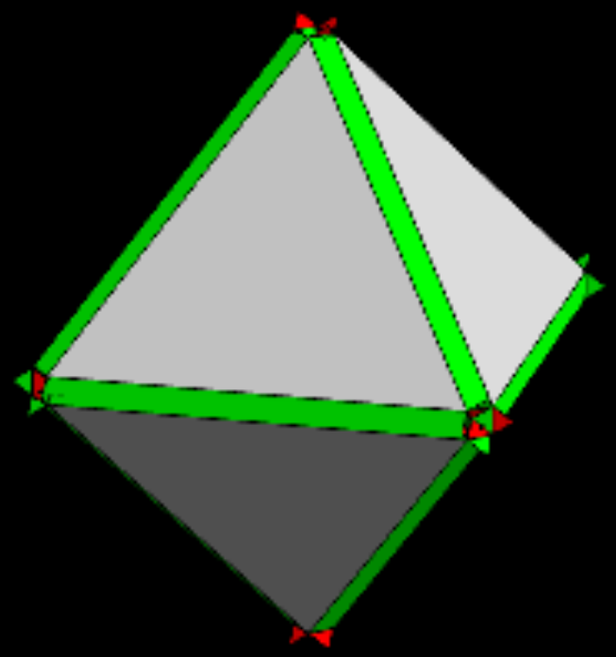
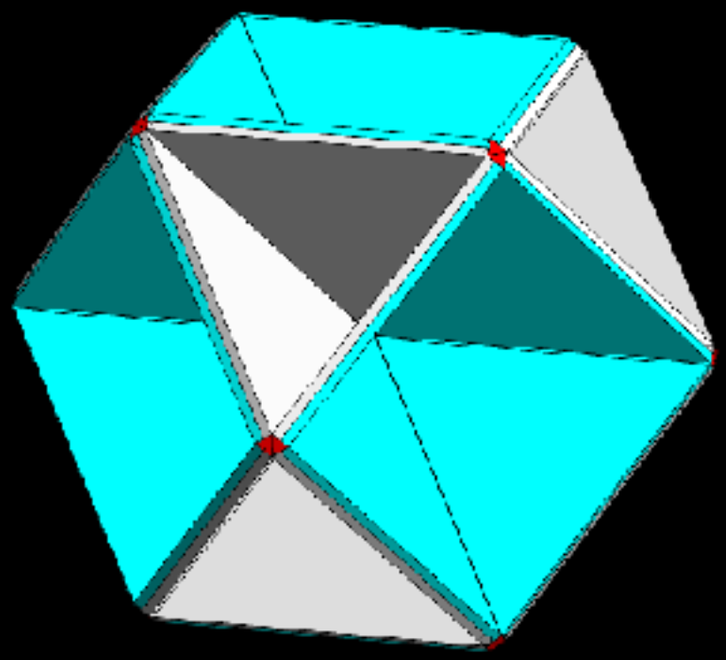
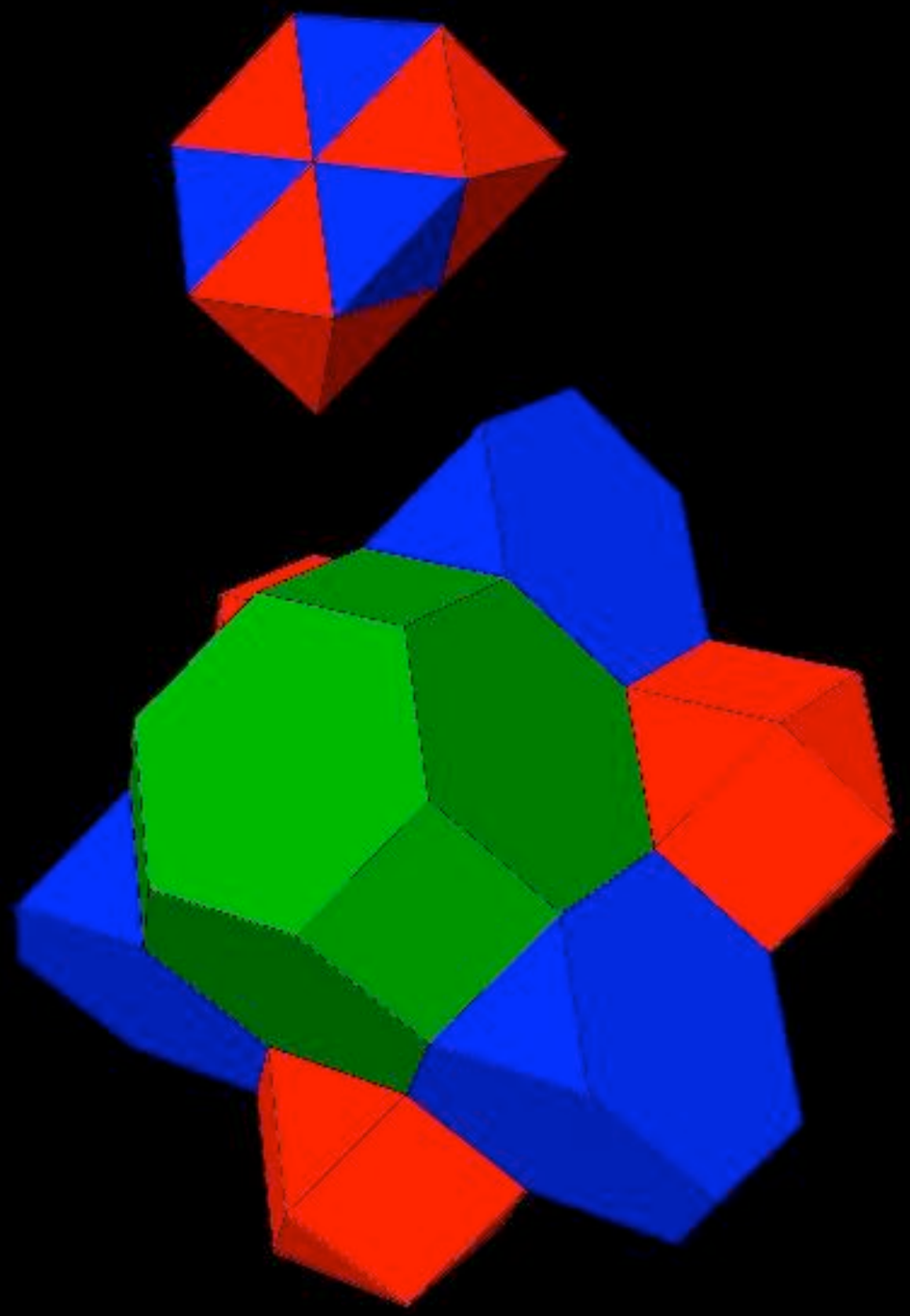


Counterrotating jitterbug

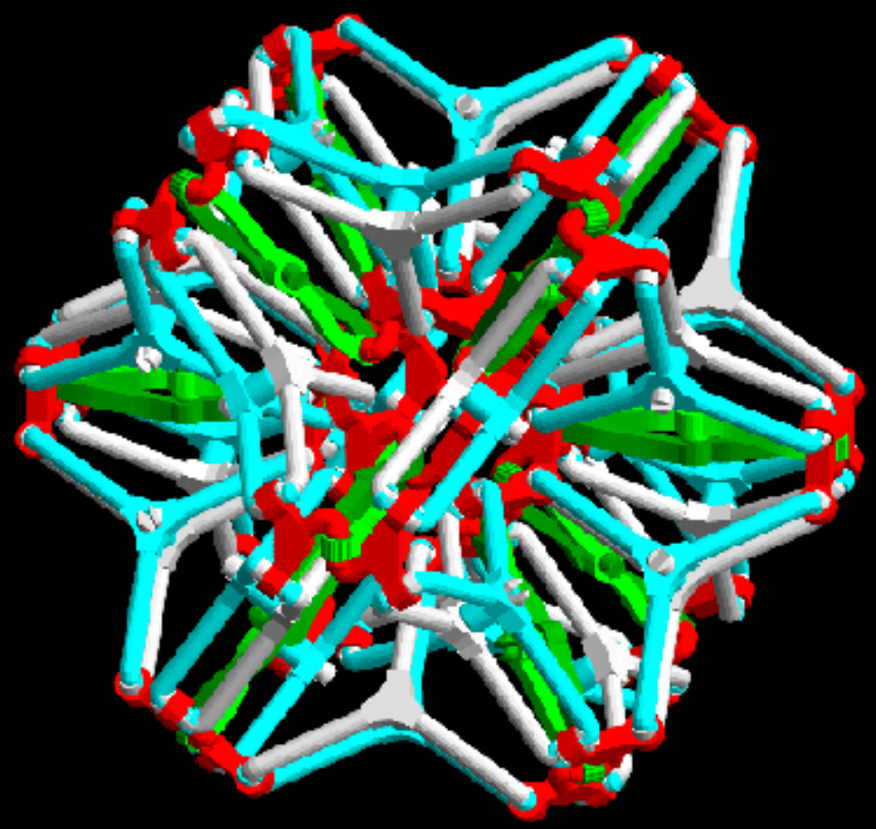


Octet/tatoh auxetic mechanism

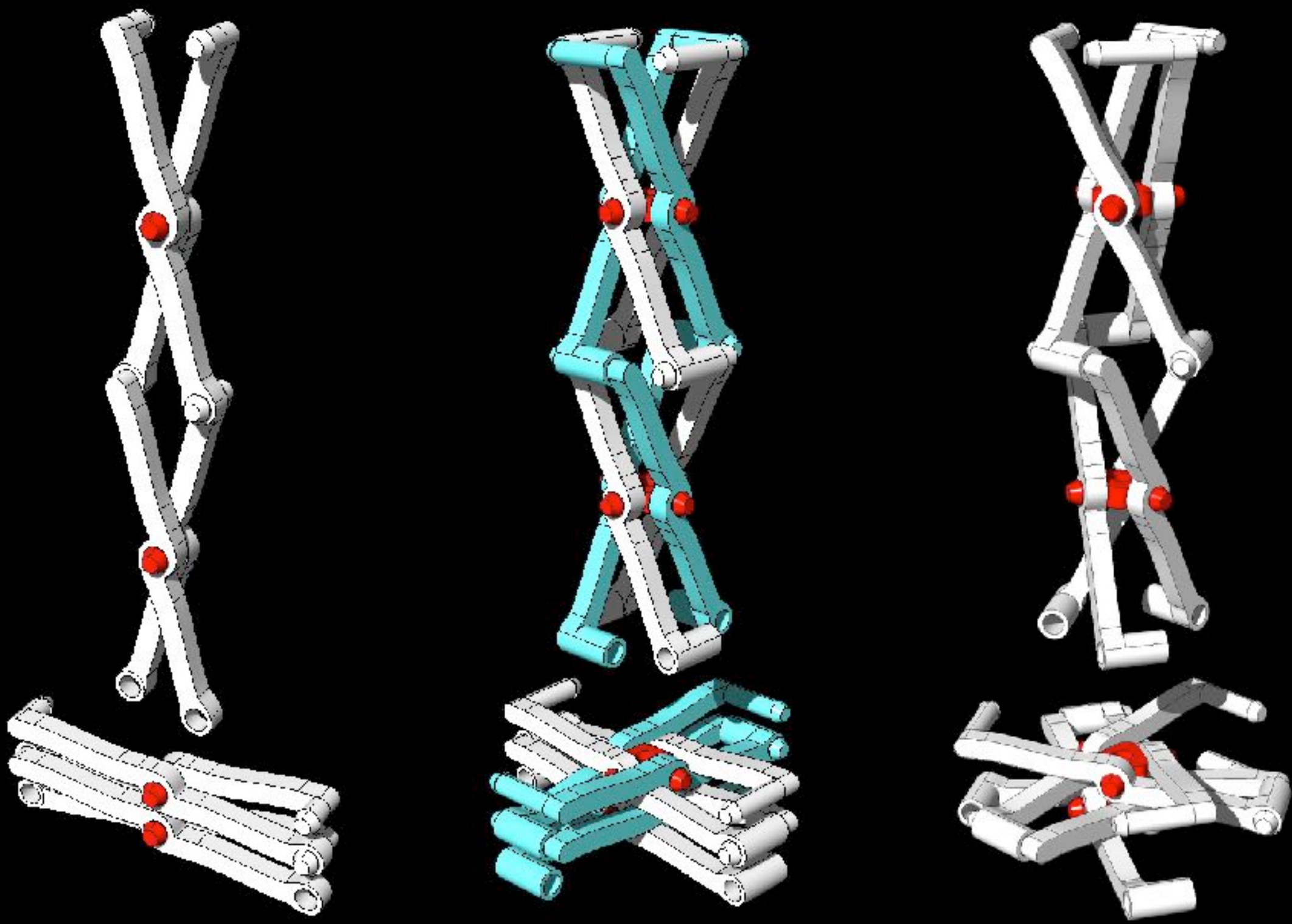




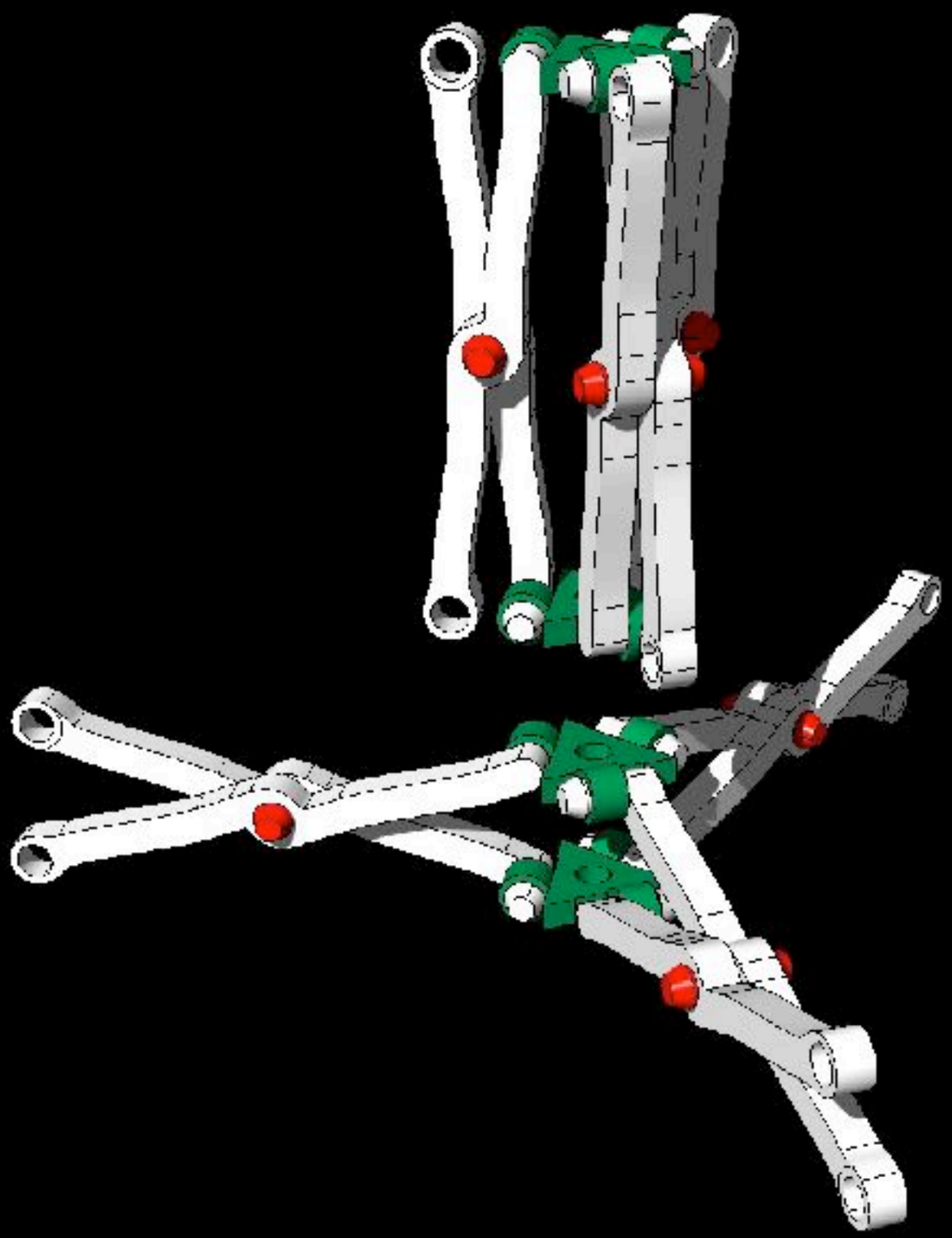
Octet/tatoh auxetic mechanism



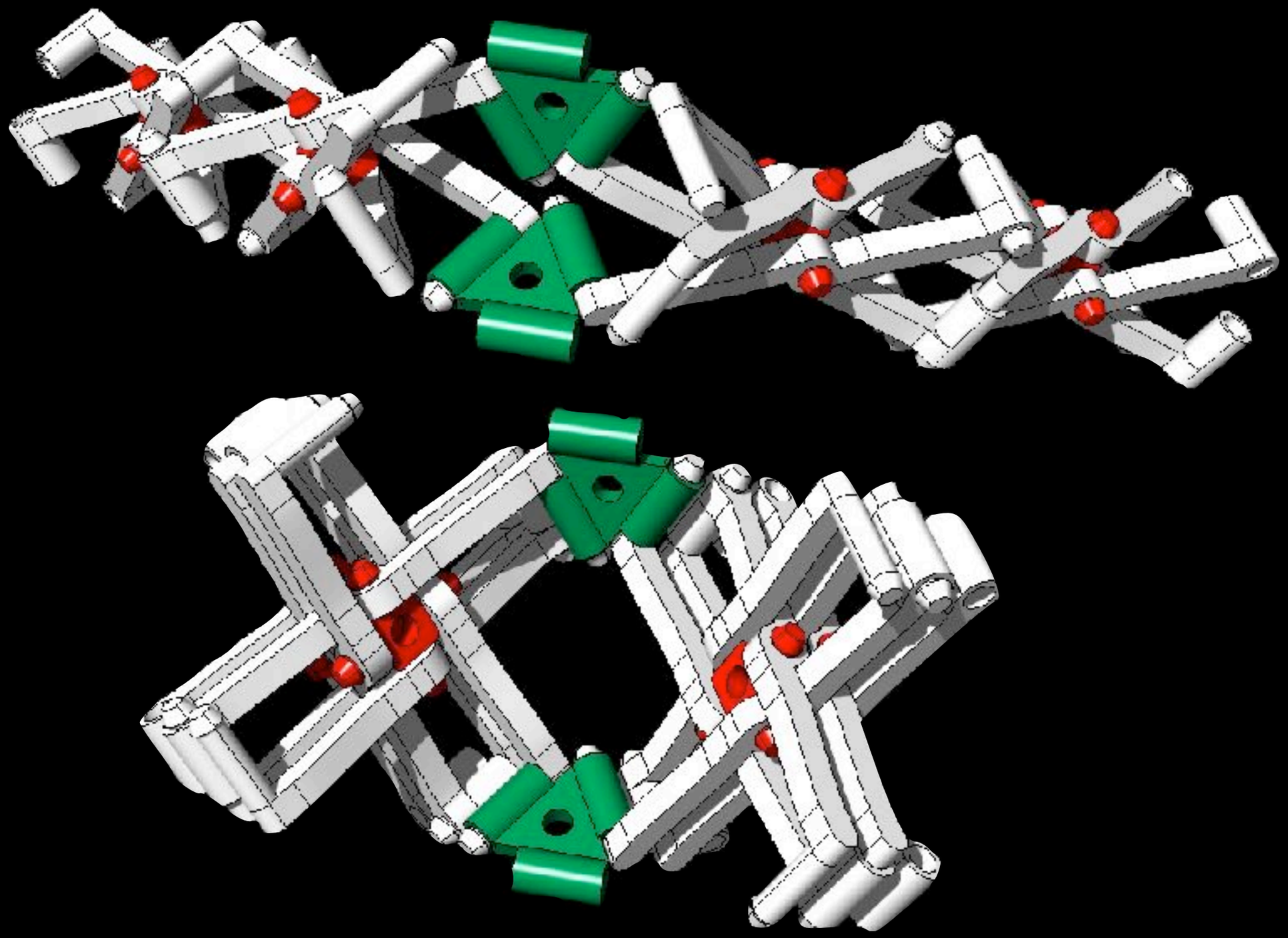
3. Branched scissor linkages



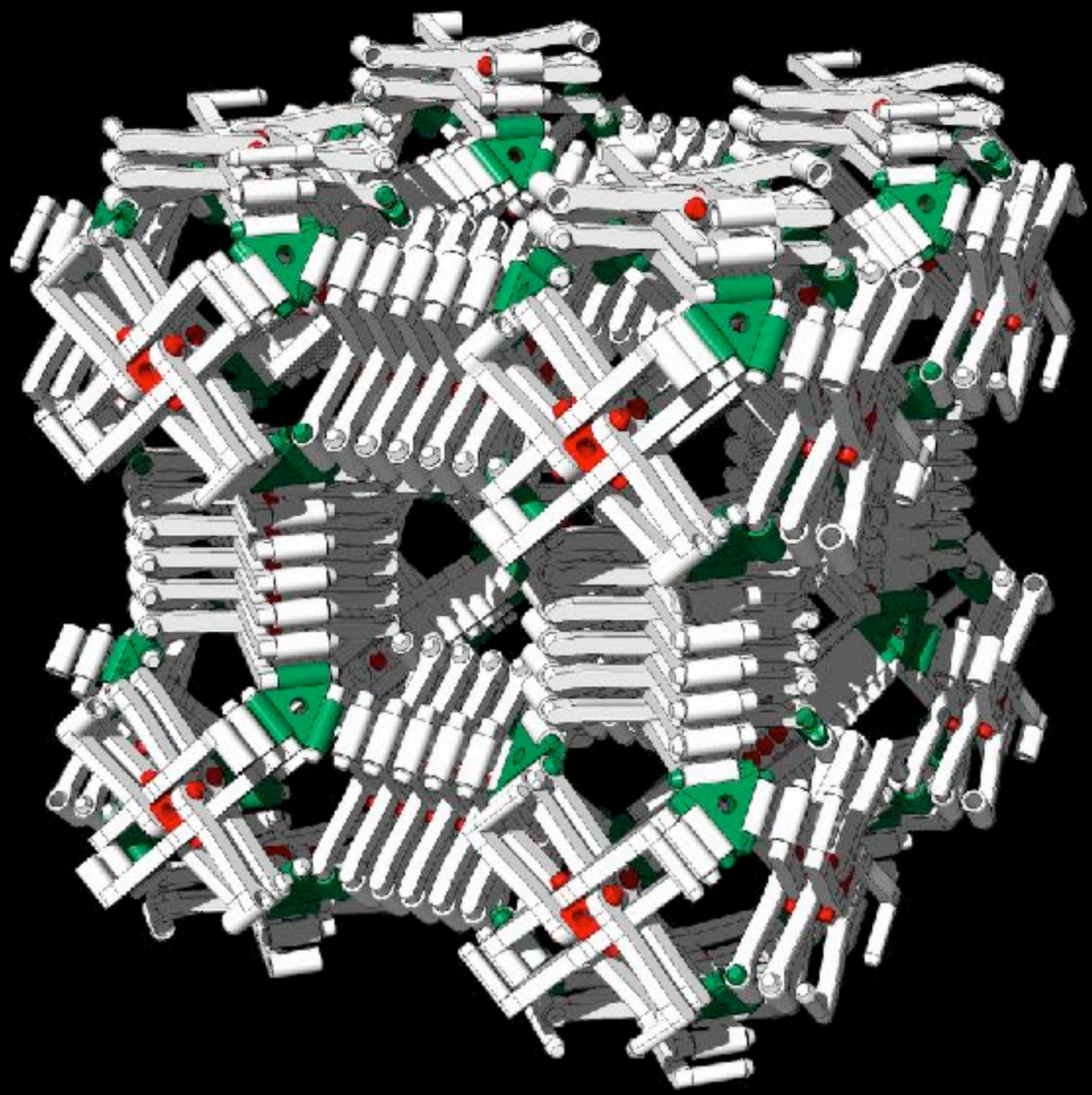
Turning corners with scissor linkages



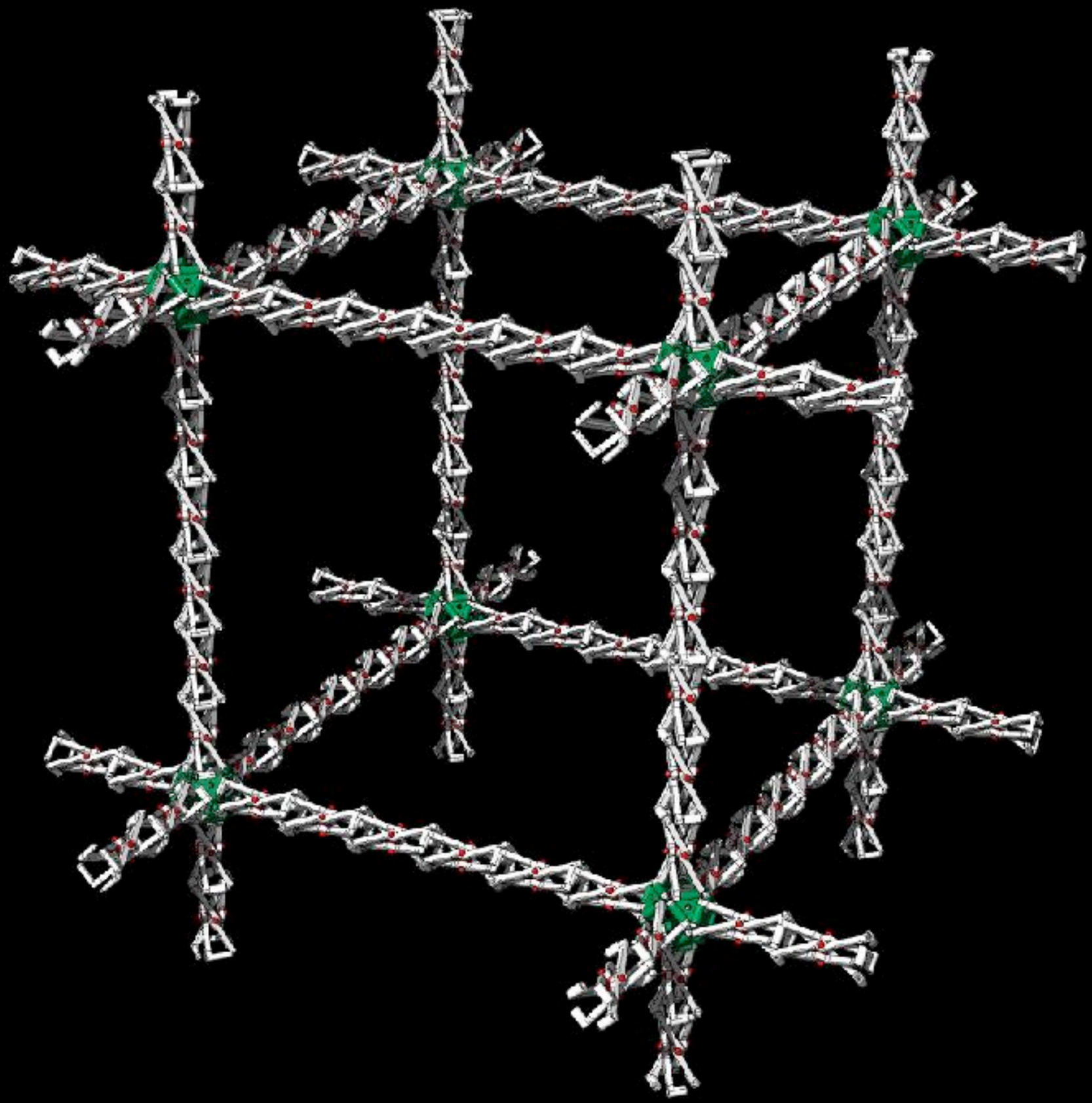
Turning corners with branched scissor linkages



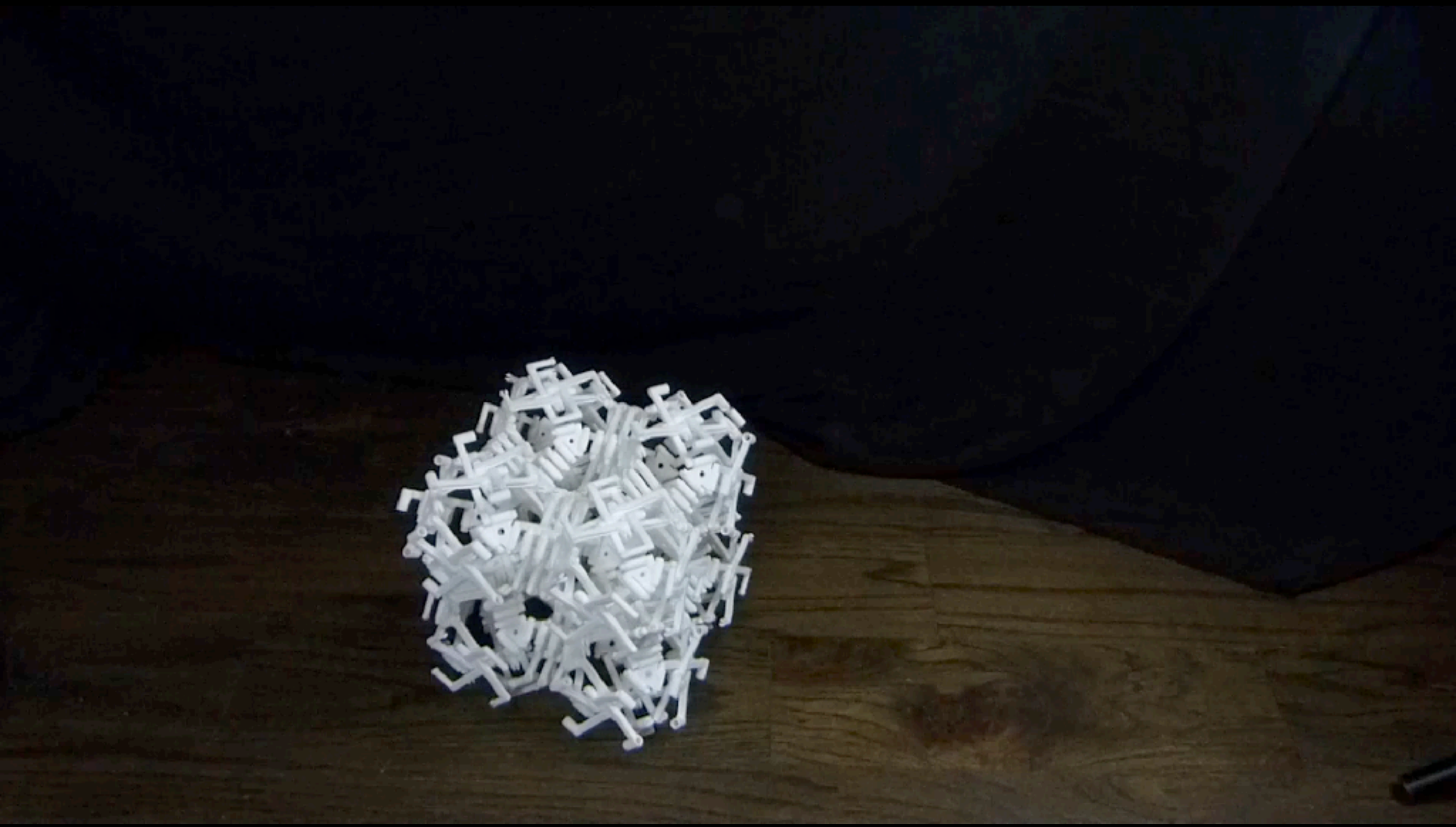
Branched scissor cube



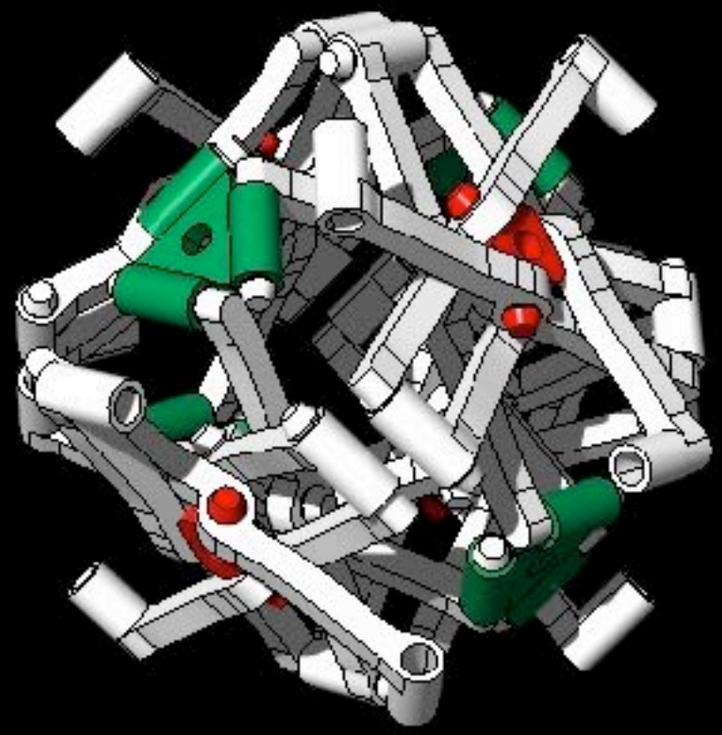
Branched scissor cube



Branched scissor cube



Branched scissor diamond



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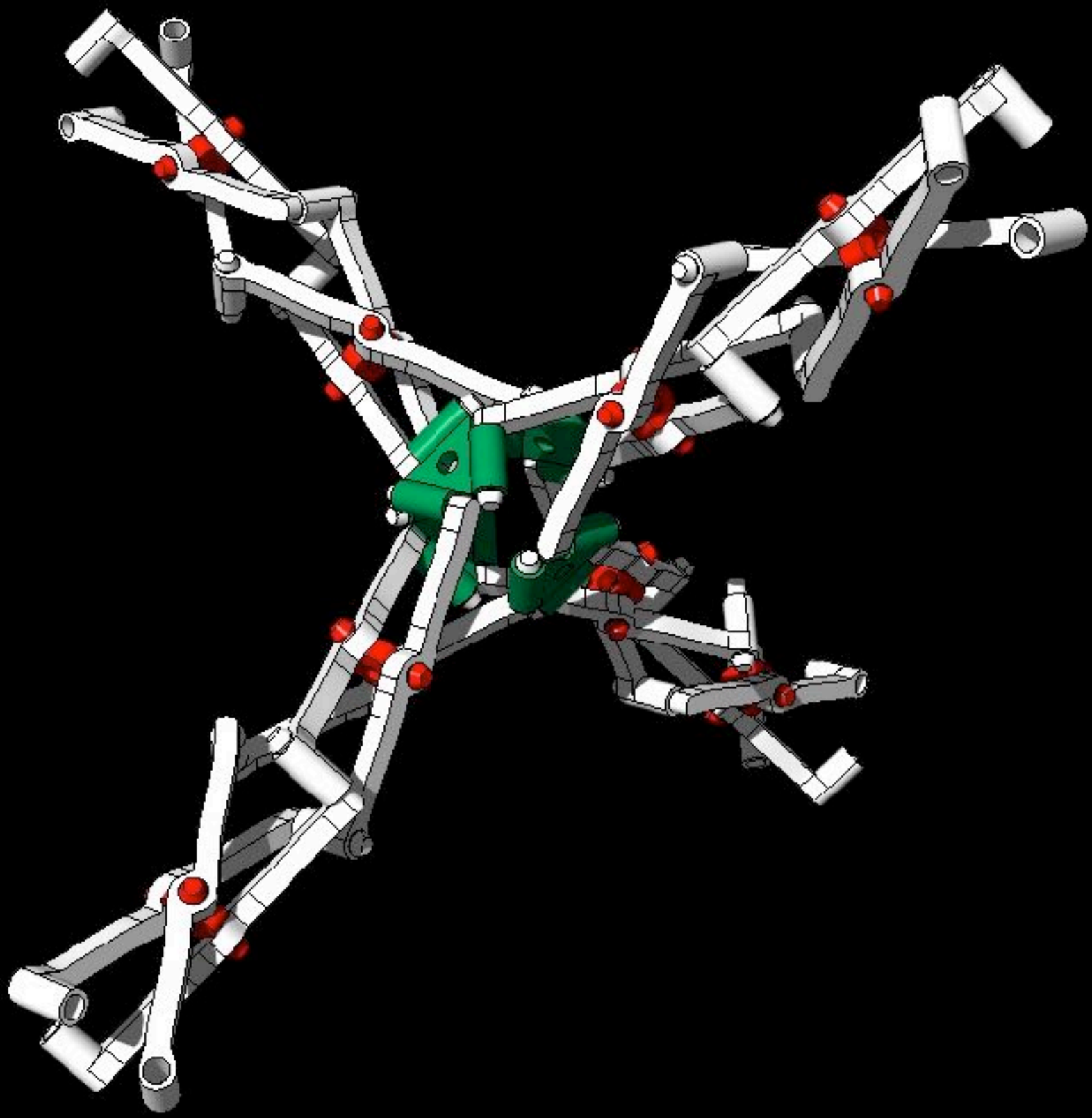
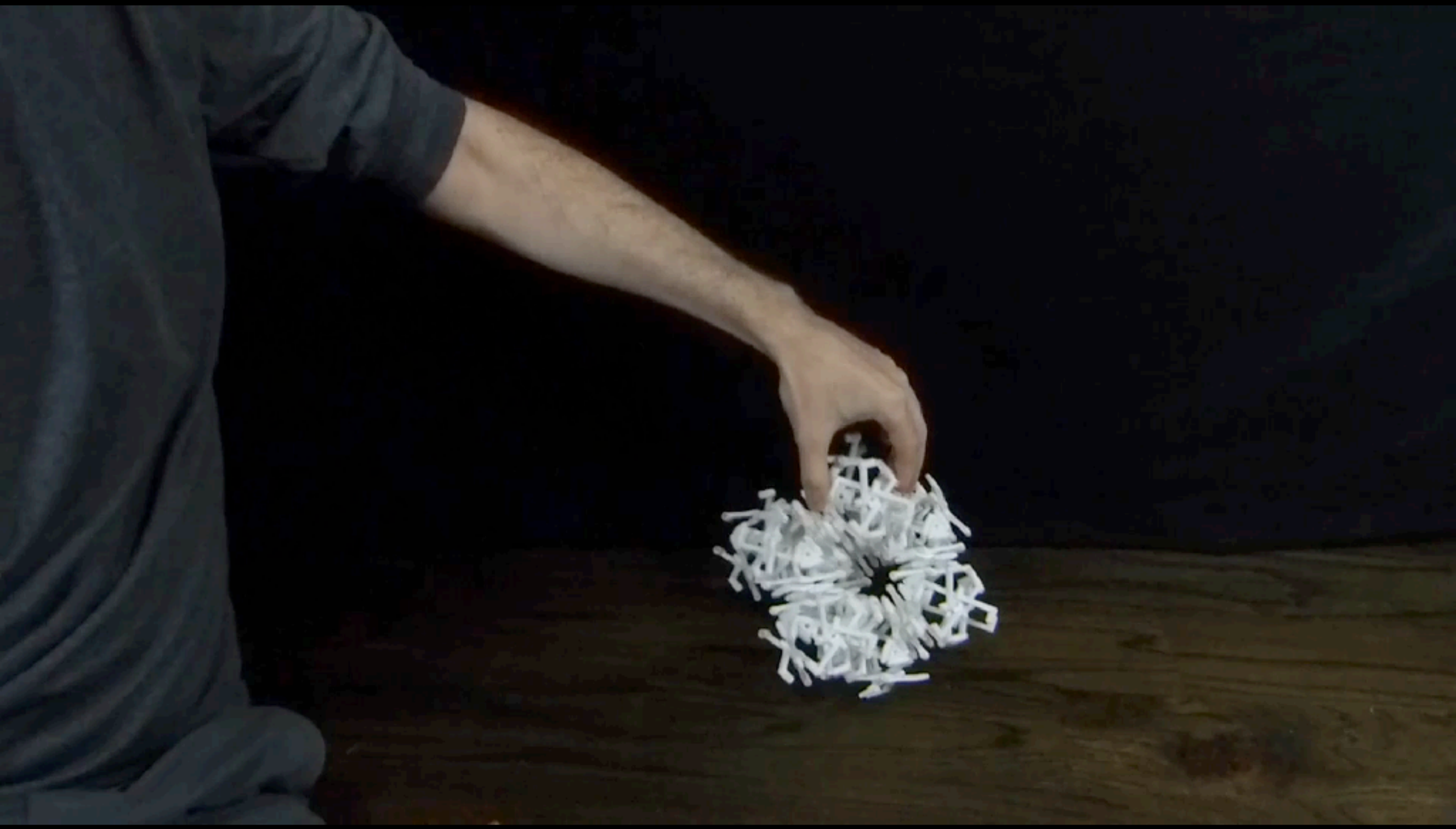
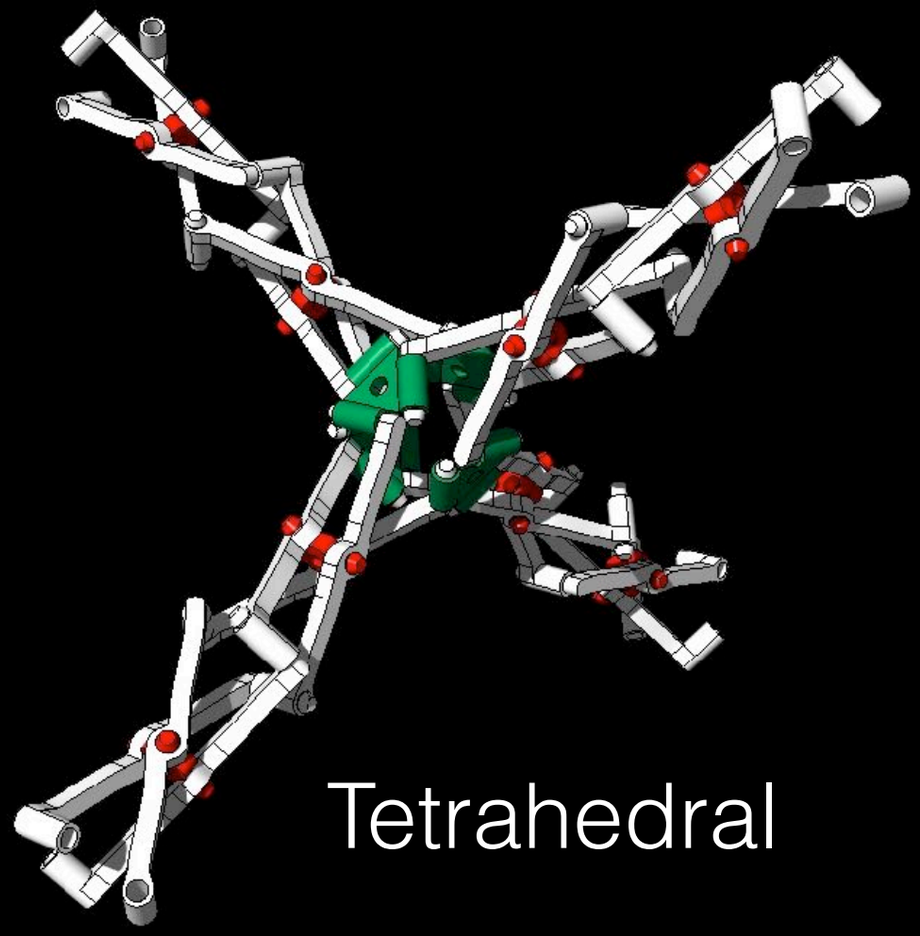


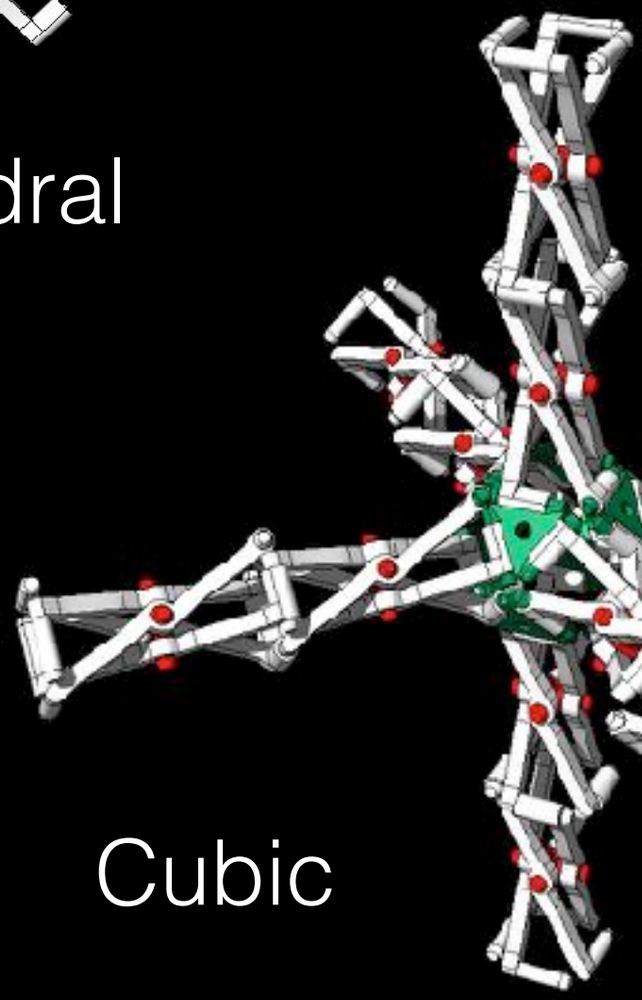
Branched scissor diamond



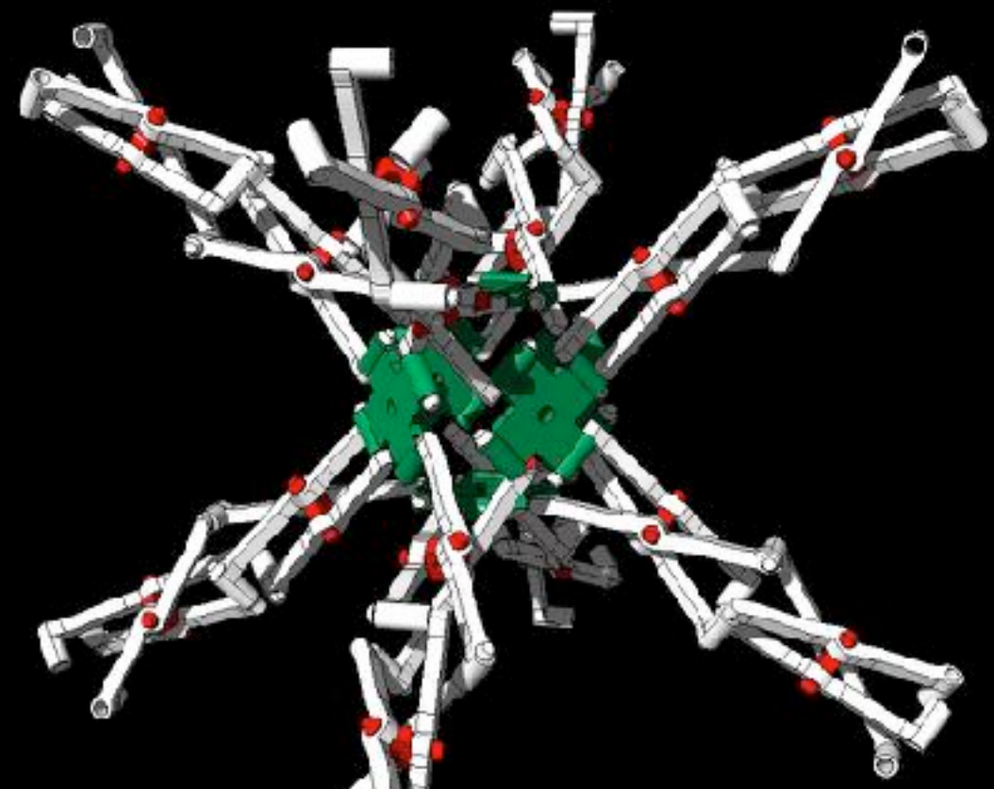
Non-planar vertex links



Tetrahedral

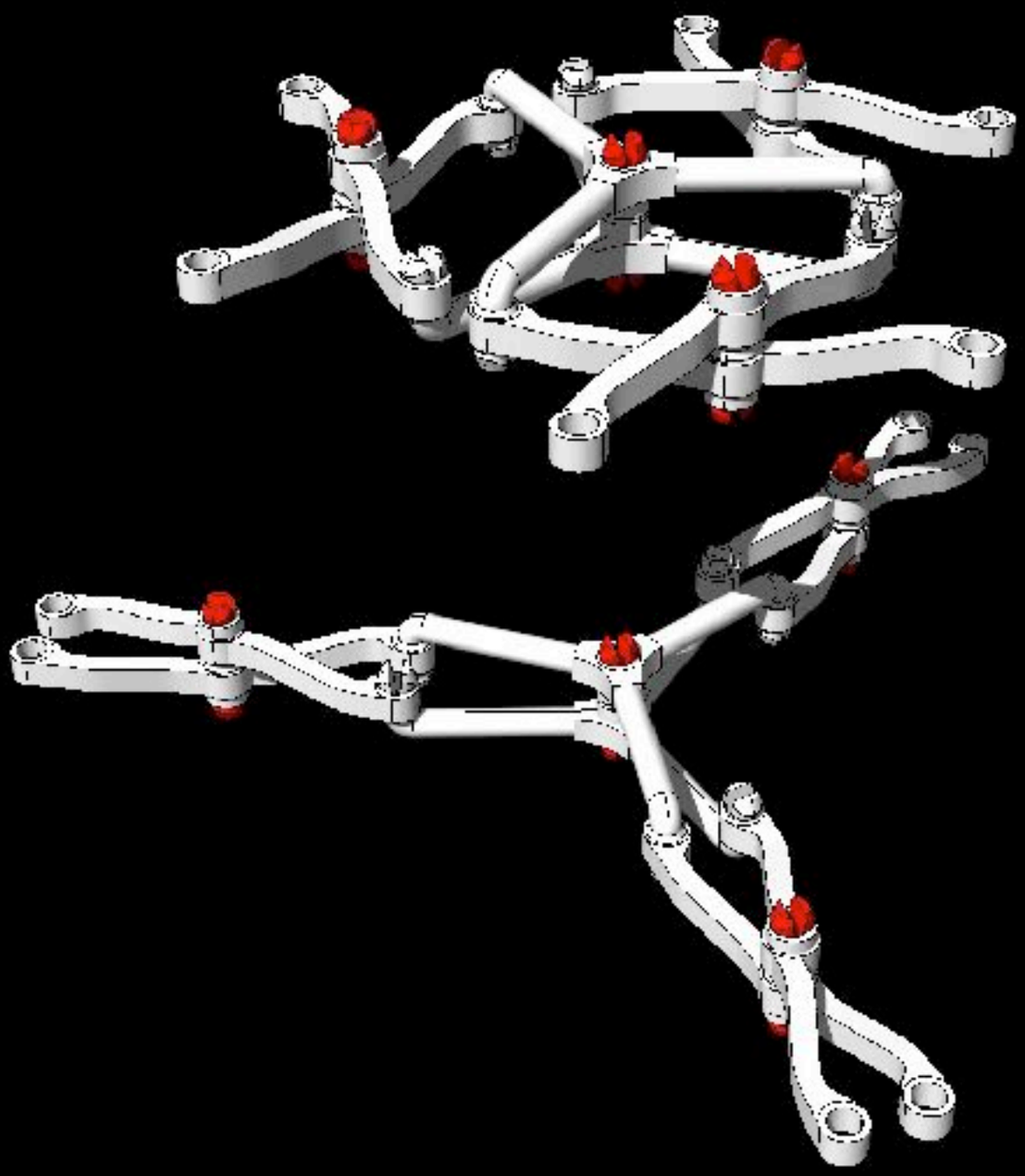


Cubic

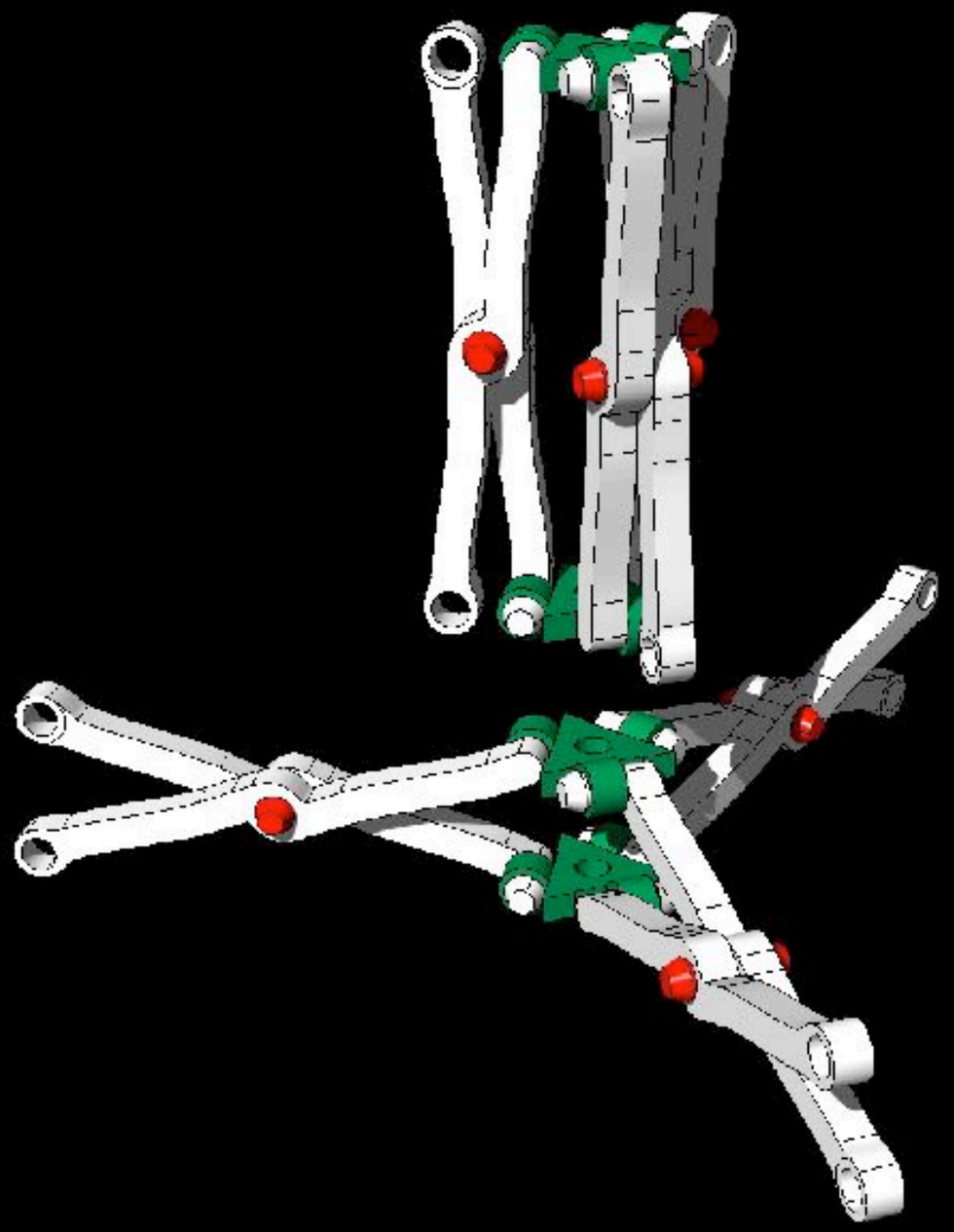


Octahedral

Planar vertex links

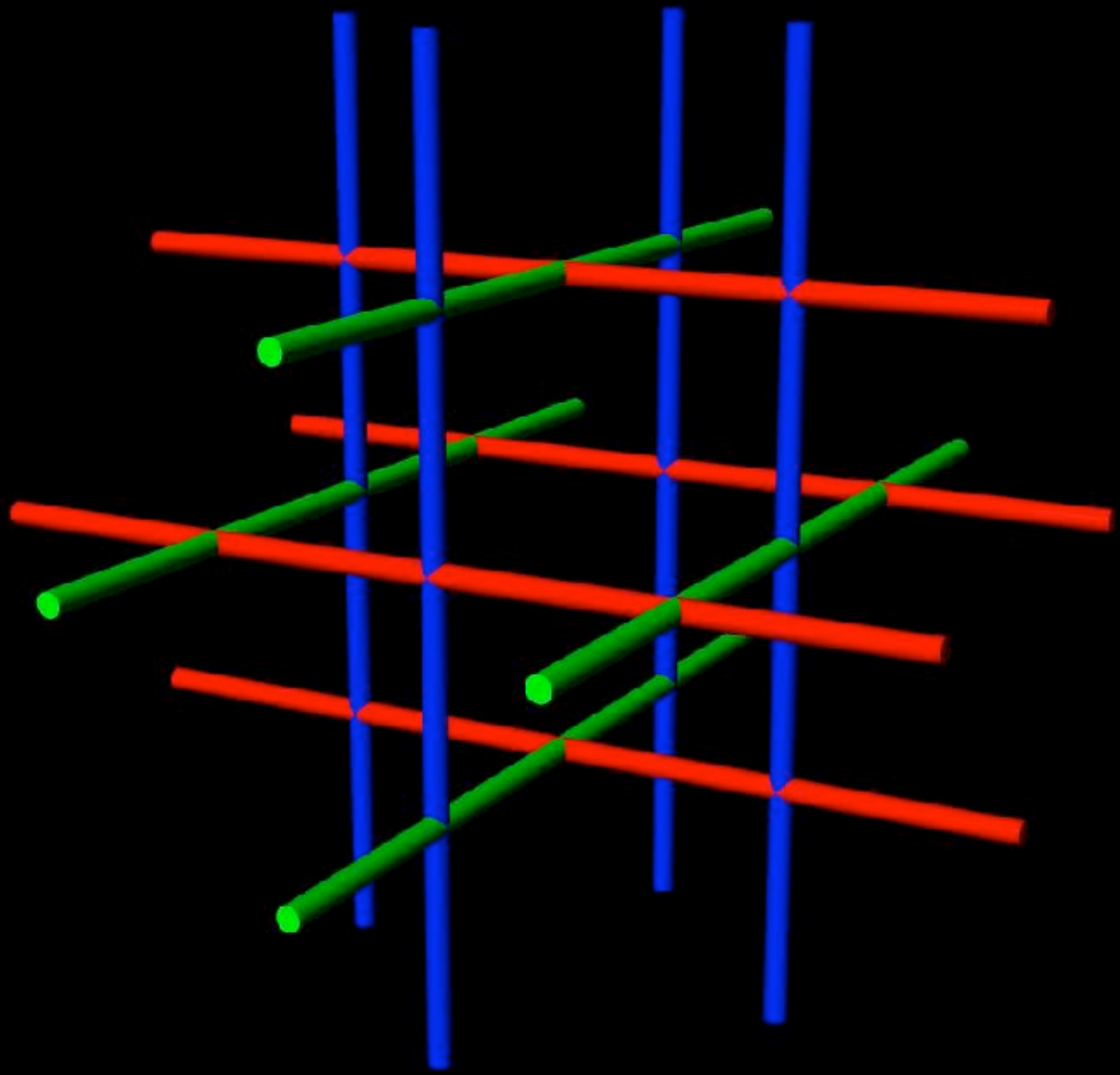


Counterrotating

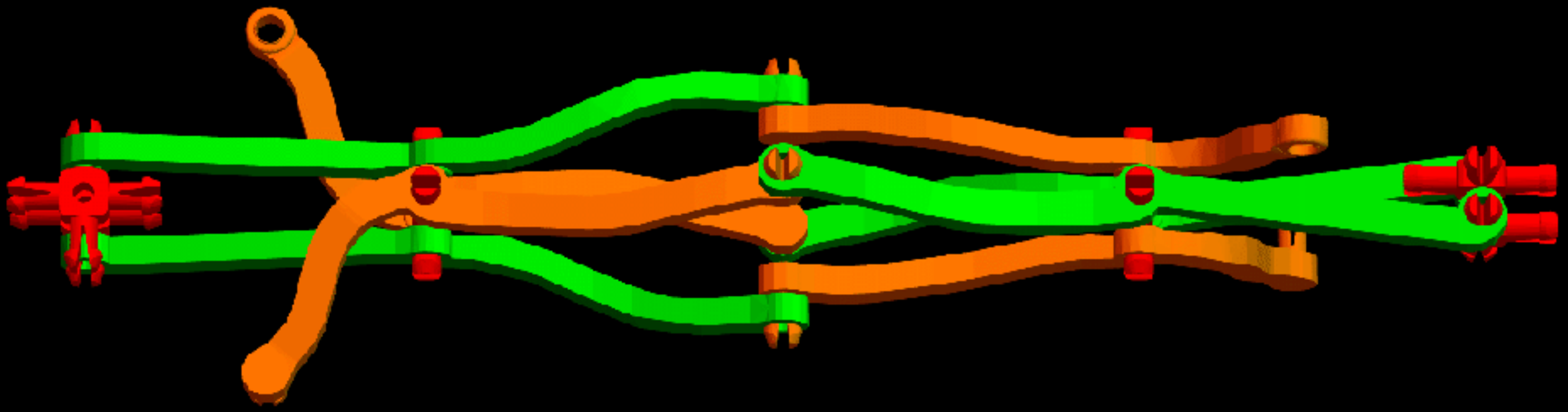


Hoberman

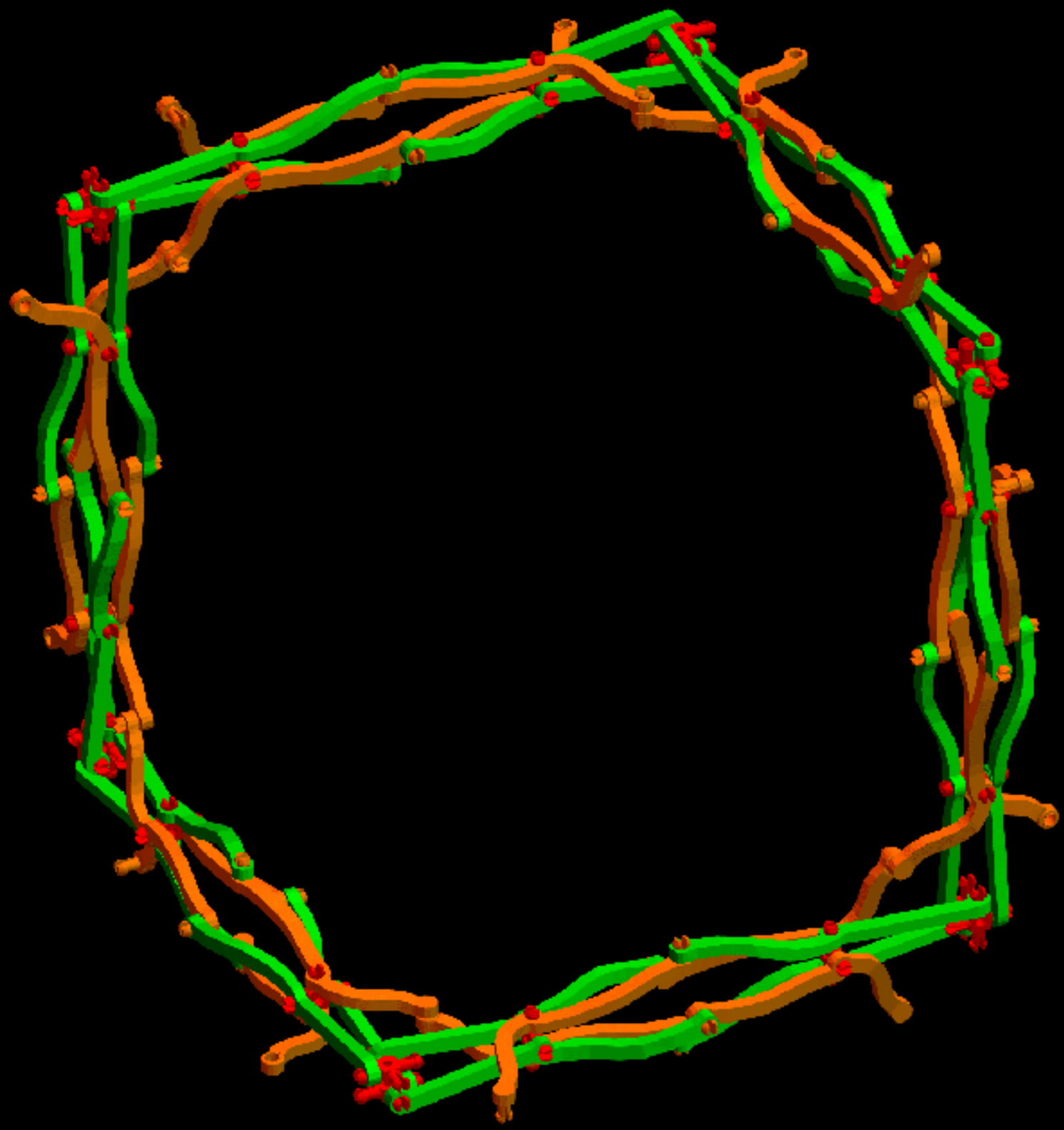
NbO lattice



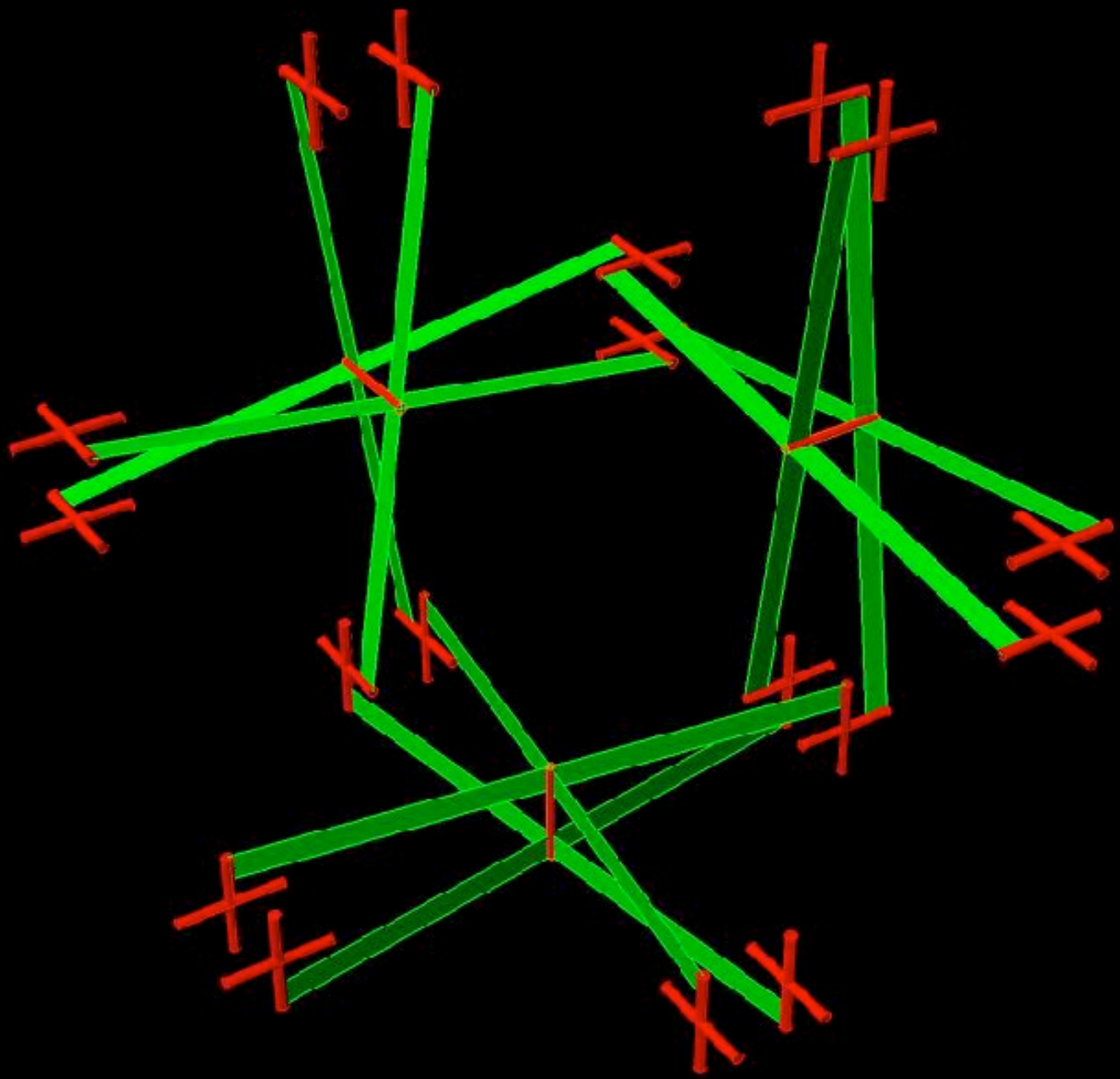
Auxetic NbO lattice



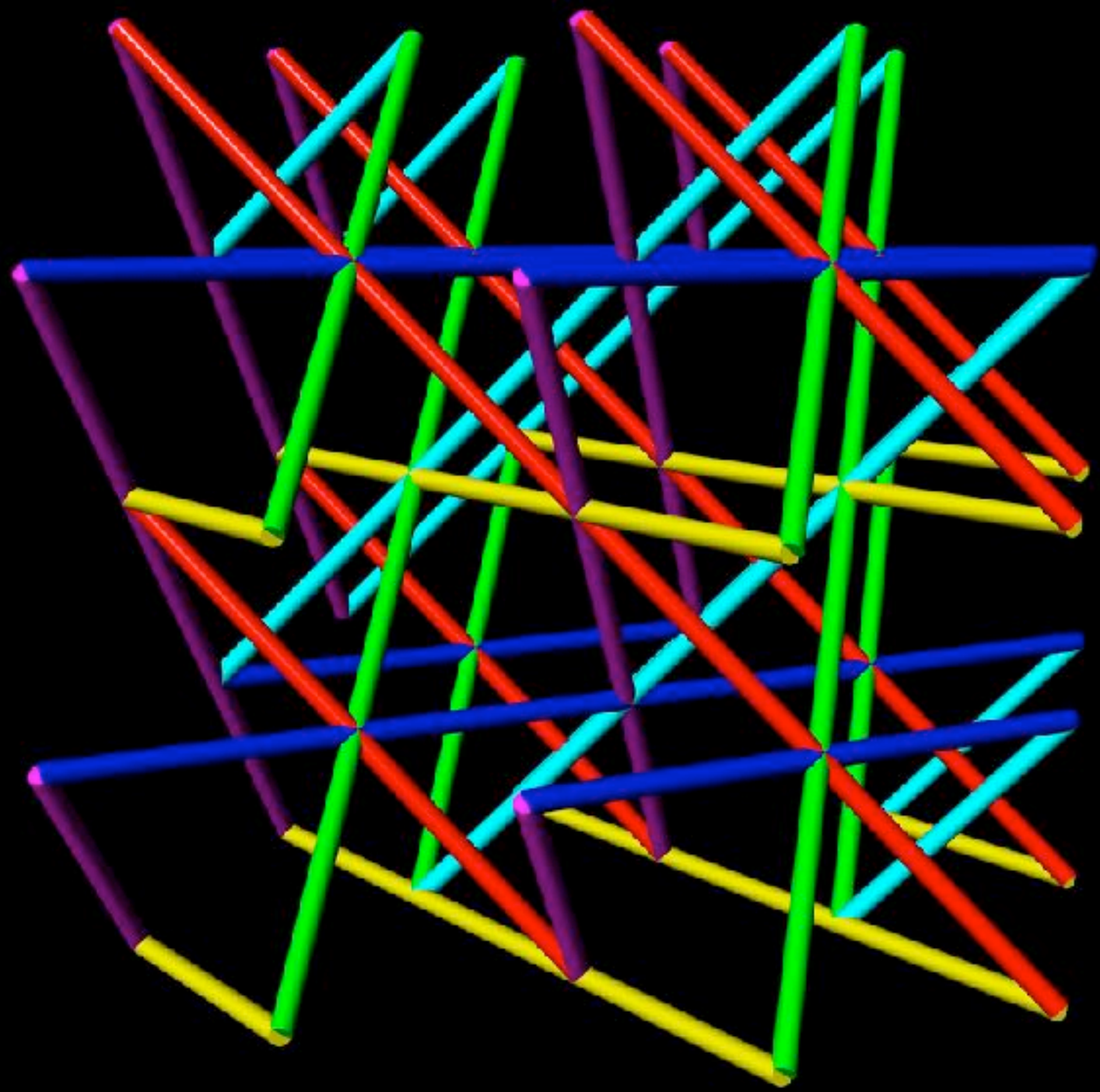
Auxetic NbO lattice



Future work:
another auxetic NbO lattice



Future work:
another lattice with planar vertex links



Thanks!