Open-boundary assemblies and geometric frustration

Particles cannot fit together perfectly on a large scale.
Strain accumulates as the structure deforms to bind new particles to its boundary.

Tuning frustration with trapezoidal puzzlemers

Simple model with easily tunable frustration and elasticity.

Self-limiting width of infinitely tall assemblies of puzzlemers

Energetics of finite-sized 2D sheets of puzzlemers

Continuum elastic theory

\[
E_{\text{strain}} = \sum \frac{1}{2} \left( \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} \right)^2 + \frac{1}{2} \left( \frac{\partial u}{\partial y} - \frac{\partial v}{\partial x} \right)^2 + \frac{1}{2} \left( \frac{\partial u}{\partial y} + \frac{\partial v}{\partial x} \right)^2 + \frac{1}{2} \left( \frac{\partial v}{\partial x} - \frac{\partial u}{\partial y} \right)^2 + \frac{1}{2} \left( \frac{\partial v}{\partial x} + \frac{\partial u}{\partial y} \right)^2
\]

Morphologies and size control of 2D sheets

Escaping frustration: out-of-plane deformations

Challenges

- Self-assembly of a polydisperse mixture of puzzlemers
- Modes of escaping frustration (e.g., buckling, defects)
- Effect of temperature (thermodynamics of GFAs)
- Experimental realization of trapezoidal puzzlemers with DNA origami colloids
- Active self-assembly (IRG 1 + IRG 2)