Soft Living Active and Adaptive Matter

Membrane mechanics meet minimal manifolds

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Abstract:

Changes in the geometry and topology of self-assembled membranes underlie diverse processes across cellular biology and engineering. Similar to lipid bilayers, monolayer colloidal membranes studied by the Sharma (IISc Bangalore) and Dogic (UCSB) Labs have in-plane fluid-like dynamics and out-of-plane bending elasticity, but their open edges and micron length scale provide a tractable system to study the equilibrium energetics and dynamic pathways of membrane assembly and reconfiguration. First, we discuss how doping colloidal membranes with short miscible rods transforms disk-shaped membranes into saddle-shaped minimal surfaces with complex edge structures. Theoretical modeling demonstrates that their formation is driven by increasing positive Gaussian modulus, which in turn is controlled by the fraction of short rods. Further coalescence of saddle-shaped surfaces leads to exotic topologically distinct structures, including shapes similar to catenoids, tri-noids, four-noids, and higher order structures. We then mathematically explore the mechanics of these catenoid-like structures subject to an external axial force and elucidate their intimate connection to two problems whose solutions date back to Euler: the shape of an area-minimizing soap film and the buckling of a slender rod under compression. A perturbation theory argument directly relates the tensions of membranes to the stability properties of minimal surfaces. We also investigate the effects of including a Gaussian curvature modulus, which, for small enough membranes, causes the axial force to diverge as the ring separation approaches its maximal value.

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Time:
9:00 AM-10:15 AM (PT)
12:00 PM-1:15 PM (ET)

About the speaker:

Dr. Leroy Jia is a Flatiron Research Fellow in Prof. Michael Shelley's Biophysical Modeling Group at the Flatiron Institute's Center for Computational Biology. He works on the applied analysis and geometry of soft, fluid, and active matter systems.

Prior to his current appointment, he studied physics and math at the Georgia Institute of Technology and obtained a Ph.D. in Applied Mathematics from Brown University under the supervision of Profs. Thomas Powers (Engineering & Physics) and Robert Pelcovits (Physics).

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