Mechanics of Colloidal Membranes

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Colloidal membranes are unique 2D assemblages consisting of a liquid-like layer monolayer of aligned rodlike viruses that are held together by osmotic pressure. Although they are a few hundred times thicker, colloidal monolayer membranes share many properties with lipid bilayers, such as in-plane fluidity and resistance to bending. However, they also display distinctive properties, such as a propensity to have exposed edges, as well as shapes with negative Gaussian curvature. Furthermore, colloidal membranes commonly have liquid crystalline properties because the rods twist near the edge of the membrane. Accounting for both the liquid crystalline degrees of freedom and the three-dimensional shape is challenging. Therefore, we develop an effective theory in which the liquid crystalline degrees of freedom are described by geometrical properties of the edge, such as edge length, curvature, and geodesic torsion. Using this theory we predict when flat membranes are unstable to twisted shape, calculate the power spectrum for the edge fluctuations, and compute the force vs. extension curve for a membrane subject to a stretching force. Our results give insight into the nature of the handedness of the ribbons as well as the sign of the Gaussian curvature modulus.