Elasticity of Networks of Semi-Flexible Polymers and Entropic Viral Membranes

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Networks of crosslinked semi-flexible polymers, including actin, neuronal intermediate filaments, and fibrin protofibrils, play an important role in controlling mechanical response of biological tissue. The elastic response of these networks is controlled by both bending and stretching energy of their constituent filaments as well as by their network architecture. Since each crosslink typically binds two filaments together at one point, the average coordination number of each crosslink is generally less than four. Arguments due to Maxwell establish that networks of nodes with coordination number $z < z_c = 2d$ in dimension d are unstable if only central stretching forces between nodes are active. Thus, bending rigidity is critical to the stability of biopolymer networks in both two and three dimension. This talk will explore various models for biopolymer networks based largely on variations of the kagome lattice [1], including a three-dimensional 4-coordinated lattice. Undiluted, these lattices consist of sample spanning filaments; when diluted they consist of finite-length filaments. The undiluted lattice can support shear and compression if the filaments are straight, but not compression and sometimes not shear if they are bent. Thus, the latter lattices require bending for stability even when undiluted. The diluted lattices exhibit a rigidity percolation threshold and strongly nonaffine, bending-dominated response upon dilution. In lattices, such as the triangular lattice, dilution produces an interesting critical crossover from stretching to bending dominated behavior [2].

If time permits, the talk will conclude with a brief description of an entropic theory of large unilamellar membranes composed of fd viruses in the presence of polymer depletants studied by the Dogic group.

[1] Mao, X. M., O. Stenull and T. C. Lubensky (2013). "Elasticity of a filamentous kagome lattice." Physical Review E **87**(4): 042602.
[2] Broedersz, C. P., X. M. Mao, T. C. Lubensky and F. C. MacKintosh (2011). "Criticality and isostaticity in fibre networks." Nature Physics **7**(12): 983-988.
[3] L. Kang, T. Gibaud, Z. Dogic, and T. C. Lubensky, "Entropic forces stabilize diverse emergent structures in colloidal membranes," Soft Matter 12, 386-401 (2016).