Two- and Three-dimensional Lattice Models for Fiber Networks with Maximum Coordination of Four.

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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 binds typically 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, including a new 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.