Topological Mechanics of Critically Coordinated Lattices

Tom C. Lubensky, University of Pennsylvania, Philadelphia, USA

Frames consisting of nodes connected pairwise by rigid rods or central-force springs, possibly with preferred relative angles controlled by bending forces, are useful models for systems as diverse as architectural structures, crystalline and amorphous solids, sphere packings and granular matte networks of semi-flexible polymers, proteins, and origami. Particularly interesting today is the increasing number of 3D-printed micron-scale metamaterials. This talk will present an overview of the elastic and vibrational properties of versions of these frames, called Maxwell lattices, whose constraints match the translational degrees of freedom of their nodes. They include the square, kagome, and pyrocholore and lattices and their modifications with nearest-neighbor central-force springs as well as jammed packings of soft spheres. Like the Su-Schrieffer-Heeger model of Polyacetylene, topological insulators, and Weyl semi-metals, these lattices have a topological characterization that in their case determines the number and nature of their zero-energy edge modes, the nature of their long-wavelength elasticity, and whether or not they have isolated topologically protected Weyl-like zero modes in the bulk. If time permits, the talk will present a mechanical model whose vibrational spectrum reproduces the electronic spectrum of graphene with different hopping for each of the three bond directions.

[1] K. Sun, A. Souslov, X. M. Mao, and T.C. Lubensky, PNAS 109, 12369-12374 (2012).
[2] C.L. Kane and T.C. Lubensky, Nature Physics 10, 39-45 (2014)
[3] T. C. Lubensky, C. L. Kane, X. Mao, A. Souslov, K. Sun, Rep. Prog. Phys. 78, 073901 (2015).
[4] O. Stenull, C. L. Kane, and T. C. Lubensky, "Topological Phonons and Weyl Lines in Three Dimensions," Physical Review Letters 117 (6), 068001 (2016).
[5] J. E. S. Socolar, T. C. Lubensky, and C. L. Kane, "Mechanical graphene," New Journal of Physics 19, 025003 (2017).