Institute for Molecular & Nanoscale Innovation
Division of Engineering

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Barus & Holley Room 190
10:00 – 11:00 am

Geometry and Symmetry in Photonics and Material Science

Building block geometry and overall structural symmetry play an important role in the design of new materials. In particular this talk investigates ellipsoid packings and photonic quasicrystals, problems in which the geometry of the building blocks and the structural symmetry determine the physical properties. Photonic quasicrystals are constructed from dielectric material arranged in a quasiperiodic pattern whose rotational symmetry is forbidden for periodic crystals. Because quasicrystals have higher point group symmetry than ordinary crystals, they can have more uniform bandgaps. Since calculating the band structure of 3D photonic quasicrystals is fundamentally challenging, and to date beyond the range of computation in a reasonable time, we decided to answer the question experimentally. We constructed the world's first and largest (in terms of the number of units) 3D icosahedral Photonic quasicrystal (compose of polymer) using stereolithography. With our novel method to make polar plots of its microwave transmission vs. frequency and incident angle, we obtained the first-ever visualization of the Brillouin zone of a quasicrystal. Before our experimental work it was not at all clear that Brillouin zones existed or had physical meaning in quasicryatals. We proved that the nearly spherical Brillouin zones of 3D icosahedral quasicrystals make them one of the most promising candidates for complete photonic bandgaps found to date. For ellipsoidal granular material packing, we found in both experiments and simulations that ellipsoids can pack randomly more densely than spheres because of their extra degree of freedom associated with their rotational axes. Discovering the fact that the packing fraction has a cusp-like minimum for spheres and increases rapidly with aspect ratio differ from unity, is important for both theoretical modeling and practical applications.

Bio: Dr. Weining Man received her Ph.D. in Physics from Princeton University (2005) under Prof. Paul M. Chaikin, the M.S. in Physics from Jilin University of China (2000), and the B.S. in Physics from Jilin University of China (1997). She was a postdoctoral fellow with Prof. William B. Russel at Princeton University and now an assistant research scientist in the Center of Soft Matter Research at New York University. She constructed the world’s first 3D photonic quasicrystal, preformed the first measurement of the photonic bandgap structure in 3D quasicrystals, and proved them to be one of the most promising candidates for complete photonic bandgaps found to date. She also investigated the order-disorder (nematic/sematic) transition of nano-scale cylinders in di-block copolymer thin-films, studied packing of granular material with different shapes, measured the capillary pressure responsible for colloid suspension film cracking, and recently started studying hydrodynamic reversibility and self- organizing in viscous colloidal suspensions under oscillating shear. Her future research will include experimental investigations and numerical simulations to study the effects of local geometry of building blocks and overall structural symmetry on the properties of artificial nano materials, especially nanophotonics.