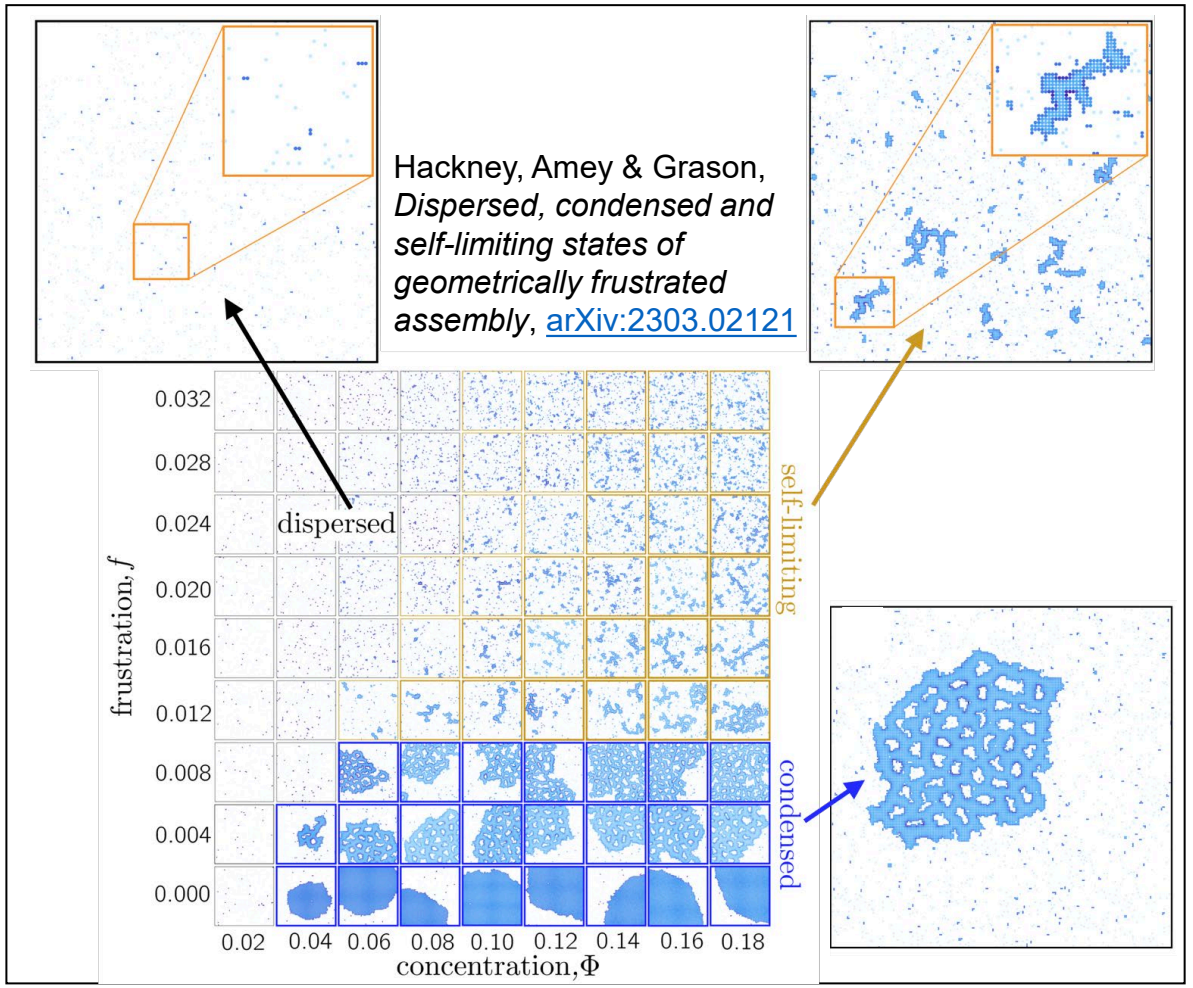
Principles of Geometrically Frustrated Assembly

Gregory M. Grason, University of Massachusetts, Amherst

Geometric frustration is most commonly used to describe how local misfit disrupts and prevents perfect order in condensed matter systems, from liquid crystals to magnetism. Recently, frustration has been theorized to give rise to exotic behavior without counterpart is standard self-assembling systems: *self-limitation*, in which thermodynamics is able to "measure" and limit the finite size of an assembling structure at sizes far larger than the assembling units or their interactions. This "thermodynamic action at a distance" has been invoked to explain anomalous structure, from existing protein to colloidal assembly, and is currently inspiring efforts to engineer size-programmed assemblies via intentionally frustrated synthetic particles.

Despite the interest in frustration-limited assembly, its physical basis remains poorly understood. Notably, basic questions remain about where and whether this exotic behavior can exist at finite temperature and concentration, necessary conditions for equilibrium assembly. A new model, which boils down the essential elements of frustrated assembly to a minimal lattice model, shows that indeed such seemingly contradictory conditions exists in which an assembly can be "feel its size through" the stresses accumulated from local misfit, yet also assemble and disassemble at finite temperature. The model makes generic predictions that the self-limiting state is only possible for intermediate strengths of misfit, dissolving when frustration is too large, and condensing into an exotic "defect sponge" when frustration is too low. Moreover, boundaries between distinct assembly states are shown to be strongly temperature-dependent, indicating that entropy plays a key role in stabilizing self-limiting assembly.



Hackney, Amey & Grason, *Dispersed, condensed and self-limiting states of geometrically frustrated assembly*, arXiv:2303.02121

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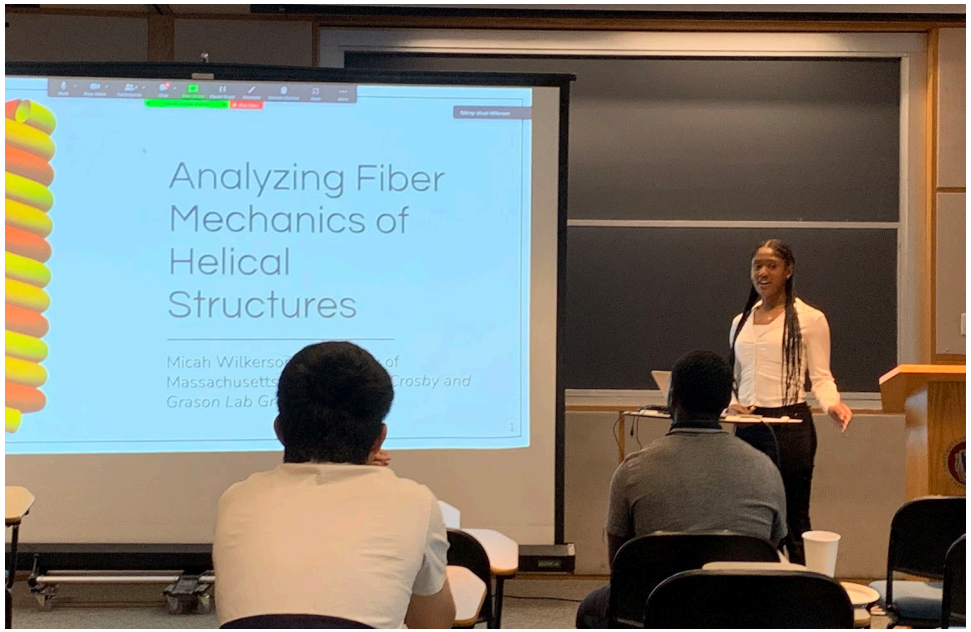
New cohort of 5 students from Holyoke High School students, joins 2023 ASPIRE program – 5 Saturdays January – in Polymer Science and Engineering for grad student led, laboratory-based intro to soft materials, including **Mohab Ramadan** (pictured in on right).



Spelman College undergrad, **Micah Wilkerson**, presents the results of her summer research project “Analyzing Fiber Mechanics of Helical Structures”, jointly advised by A. Crosby at UMass, July 2023.