Master's thesis and/or Ph.D. thesis opening

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Emergence of fibers in frustrated self-assembly

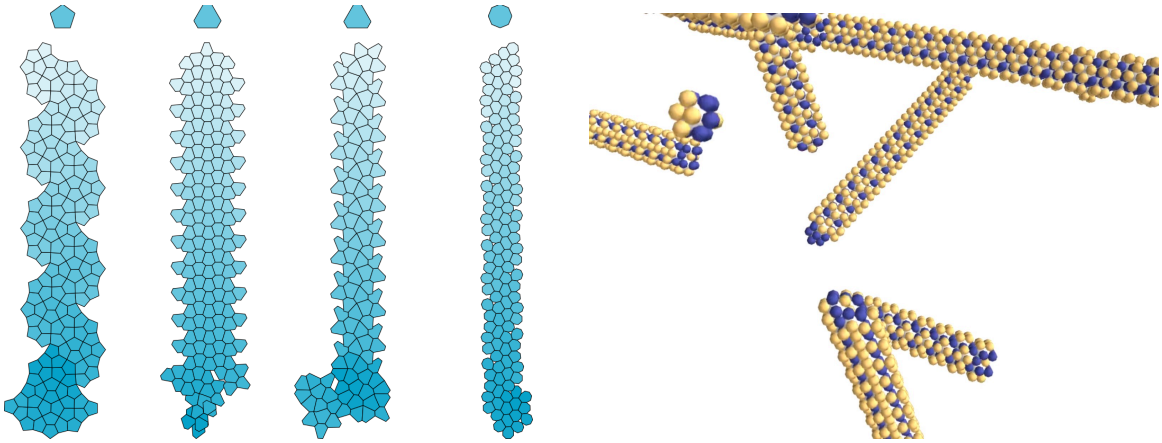
(theoretical thesis)

Self-organization is key to the function of living cells – but sometimes goes wrong! In Alzheimer's and many other diseases, normally soluble proteins thus clump up into pathological fiber-like aggregates. While biologists typically explain this on the grounds of detailed molecular interactions, we have started proving that such fibers are actually expected from very general physical principles. We thus show that **geometrical frustration builds up when mismatched objects self-assemble, and leads to non-trivial aggregate morphologies, including fibers.**

Despite several examples of this in our numerical simulations (see illustration), we have yet to better understand the underlying physics. Is fiber formation based on a well-defined phase transition? Is this transition fundamentally out of equilibrium as some of our results suggest? To what extent can it be mapped onto the standard geometrical understanding of frustration as the embedding of a manifold into a space with an incompatible metric? We will tackle these questions using **two minimal models of frustration where we hope to combine analytical and numerical insights**. One of these is akin to historical descriptions of Josephson junctions, where lattice-based Heisenberg spins want to realize a certain fixed mismatch in their alignments between neighboring sites.

This project offers opportunities for collaborations with the theoretical group of Gregory Grason at U. Mass. Amherst (USA), as well as with several groups that are currently initiating experiments on frustration-driven fiber formation.

Informal inquiries welcome.



Fibers obtained in simulations of frustrated deformable polygons (*left*), and of lattice particles with geometrically incompatible orientational preferences (*right*).