Master 2 internship proposal

Physique et Mecanique des Milieux Heterogenes

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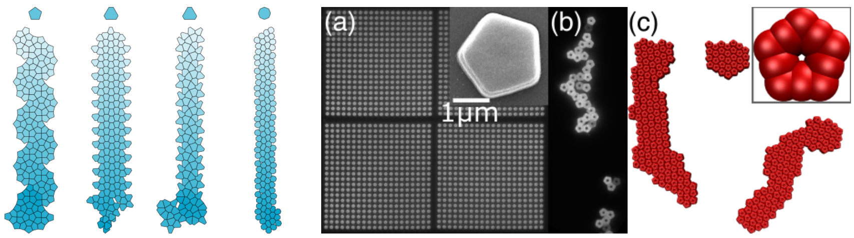
Internship location: Laboratoire PMMH

Self-Assembly of irregular micro-particles

Self-assembly is a key feature of living cells, which organize their basic components into complex machines based on their mutual interactions. Most of the time, it brings well-adjusted parts together into functional structures such as the ribosome or viral capsids. In other cases however, objects that are not optimized by evolution to fit nicely self-assemble nonetheless, leading, e.g., to protein-aggregation diseases. While functional self-assembly has attracted increasing attention due to rapid progress in nanofabrication, the basic physical principles underpinning the assembly of ill-fitting objects remain largely unknown. The conceptual advance at the heart of our project is that ill-fitting particles self-assemble into low-dimensional aggregate morphologies not easily achieved with well-adjusted particles (see figure on the left and reference [1]). We term this effect dimensional reduction. During this Master internship we propose to investigate this dimensional reduction by self-assembly experiments using irregular colloids printed in 3D with submicron-resolution. We will base our investigations on Brownian dynamics simulations held in Martin Lenz groups at LPTMS (Orsay) to help sort through the huge diversity of potential particle shapes accessible through 3D-printing.



Left: One-dimensional aggregates formed by identical particles (shown at the top) that cannot fit together to tile the plane unless deformed. Right: Our fluorescent 3D-printed particles (a) arranged in a regular array after printing and before detachment from the substrate and (b) after aggregation and their (c) numerical counterparts. Insets show individual particles.

We will manufacture micron-sized colloids of arbitrary shapes with our Nanoscribe 3D-printer (installed at PMMH), which can produce large numbers of ill-fitting colloids at a â 100 nm resolution (see figure on the right (a)). These colloids sediment in water and aggregate in two dimensions at the bottom of the chamber (figure right (b)). As dimensional reduction sensitively depends on inter-particle interactions, we will control them through PEG-induced depletion forces. The PEG concentration will determine the strength of the interaction, while using different PEG chain lengths will modulate its range.

References [1] Martin Lenz and Thomas A. Witten. Geometrical frustration yields fibre formation in self-assembly. Nat. Phys., 13:1100, 2017.

Expected skills: The project is primarily experimental and includes some image analysis of the observed phenomena.
This master internship will ideally be continued during a PhD starting next fall.