Designing active matter systems with light

Antoine Aubret
Department of Physics, University of California San Diego, La Jolla, USA

Biological living systems are prototypical examples of Active Matter, where self-driven units convert energy into motion or work. This allows cells, for instance, to exhibit far-from-equilibrium behavior such as autonomous regulation or organization. This success of biology challenges our ability to engineer synthetic analogs and control self-assembly. In this talk, I will show how we can carve non-equilibrium pathways for the controlled self-assembly of active microparticles using light as a tool.

We use photocatalytic colloidal microparticles as primary building blocks for self-assembly. We specifically designed the particles to self-propel, and sense and migrate in light gradients. Following sequential light-patterns, the particles autonomously assemble into robust self-spinning structures, or microgears. The gears interact and act like cogwheels with contactless 'teeth', synchronizing their motion. We characterize the interaction potential of the gears following a statistical analysis of the density of fluorescent tracers and compare it to numerical calculations. Our results show that the synchronization originates from the coupling between the chemical clouds generated by the catalytic activity of the gears.

Following, the gears are used as new building blocks and constitute the fundamental components of synchronized micro-machineries that auto-regulate and whose dynamics is tuned by the spins of their internal components.

Finally, we further demonstrate a new approach, *templated assembly,* which exploits optical forces and the activity of the colloids to create ensembles of self-spinning microgears of well-defined chirality.

Our study demonstrate the potential of light to manipulate non-equilibrium interactions and program the self-assembly of dynamical colloidal architectures beyond static, equilibrium assemblies.