Probing and designing matter with light

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Light is a powerful tool to control complex systems at micro and nanoscale, as it provides flexible and precise (submicron) spatiotemporal modulation.

The first part of this talk focuses on the light-guided self-assembly of colloidal building blocks. In Nature, energy input is needed to develop advanced features, e.g. self-healing or self-regulation. I will show how we can extend this principle to the artificial world by the self-assembly of dissipative components that respond to light cues [1]. Following sequential light-patterns, they autonomously assemble into robust self-spinning structures, or microgears. The gears act as contactless 'teeth', synchronizing their motion, and constitute the fundamental components of synchronized micro-machineries that auto-regulate and whose dynamics is tuned by the spins of their internal components. The study demonstrate the potential of non-equilibrium interactions to program self-assembly and control dynamical colloidal architectures beyond static, equilibrium assemblies.

In a second part I will show how luminescent nanoparticles can be exploited to probe complex soft matter systems. The local refractive index, in particular, can give critical physical and structural information but can be hard to characterize in strongly heterogeneous media.
Here, we use colloidal CdSe/ZnS quantum dots and their excitonic lifetime to probe the local refractive index [2]. We start by analyzing their sensitivity to the local dielectric environment and quantify their performance as nanoprobes, in particular in comparison of plasmonic nanoparticles. Finally, we demonstrate the use of Fluorescence Lifetime Imaging (FLIM) with quantum dots to map the intracellular refractive index.

[1] A. Aubret, M. Youssef, S. Sacanna and J. Palacci, "Targeted assembly and synchronization of self-spinning microgears" Nature Physics, 2018
[2] A. Aubret, A. Pillonnet, J. Houel, C. Dujardin and F. Kulzer, "CdSe/ZnS quantum dots as sensors for the local refractive index", Nanoscale 8 (2016) 2317–2325.