The Physics and Engineering of Active Matter

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1. Abstract

Dense suspensions of swimming bacteria display striking motions that look extremely vivid when compared to the thermal agitation of colloidal particles of comparable size. These suspensions belong to a wider class of non-equilibrium systems that are now collectively referred to as active matter [1]. Research in active matter physics deals with the fundamental aspects underlying some distinctive properties of these systems, such as the emergence of collective behavior and rectification phenomena. From a more engineering perspective, however, active matter can be looked at as a special kind of fuel: a small droplet of an active fluid can be used to propel micro-machines inside miniaturized chips, with no need of external driving fields or control. Using advanced tools for 3D optical imaging, manipulation and fabrication we study complex phenomena in active matter with direct and quantitative methods. I will review our recent work in this direction, from off-equilibrium transport and stationary states in active matter [2] to the use of genetically engineered bacteria as controllable propellers for synthetic micro-machines (Fig. 1) [3].

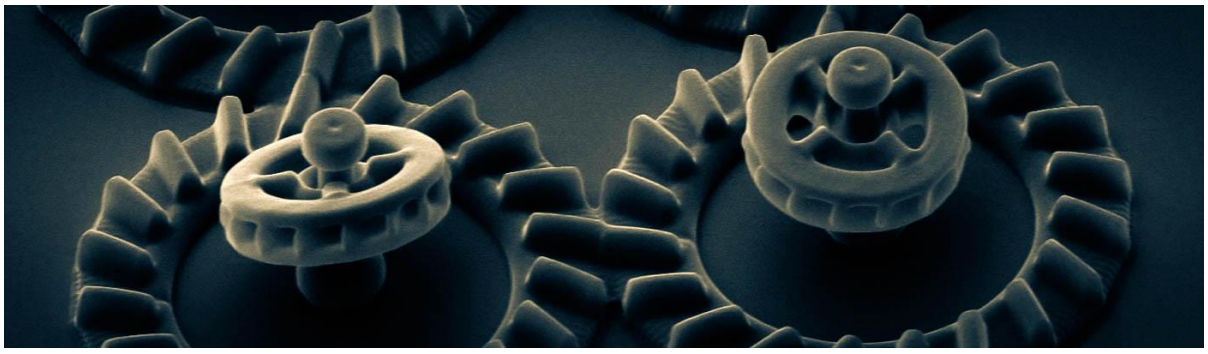

Figure 1: SEM image of rotary micromotors driven by bacteria.

References

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[2] N. Koumakis et al. Targeted delivery of colloids by swimming bacteria, Nature Communications, 4, 2588, (2013).
[3] G. Vizsnyiczai et al. Light controlled 3d micromotors powered by bacteria, Nature Communications, 8, 15974, (2017).