ParisTech ESPCI PARIS PSL

RESEARCH TOPIC FOR THE PARISTECH/CSC PHD PROGRAM

Field: Physics
Subfield: Hydrodynamics
Title: Micro-helices in flows
ParisTech School: ESPCI Paris | PSL
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Short description of possible research topics for a PhD:

The study of fluid structure interactions between helix-shaped particles and viscous flows is of importance for both fundamental science and technological applications. The chirality of such particles induces breaking of the time reversal symmetry associated with viscous flows; an effect exploited by microorganisms, such as E. coli bacteria, which propel themselves through viscous media by rotating helically shaped flagella. Particle chirality has also been shown to induce a lateral drift in shear flows, responsible for example for bacterial rheotaxis. Possible applications include swimming micro-robots for targeted drug delivery or flow micro-sensors. We have recently developed several experimental model systems to investigate the interaction between helical micro-particles and viscous flows (see figure). These micro-objects are put under flow in specifically designed microchannels and followed during their transport.

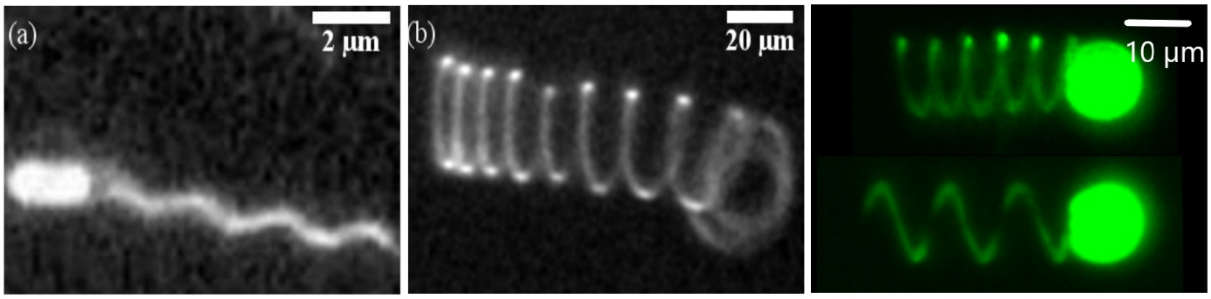

Figure 1a) Fluorescent imaging of E-coli bacteria, (copyright H. C. Berg). (b) Flexible helix observed under fluorescent microscopy, clamped on its right. (c) Microprinted helix with a head.

In this PhD we suggest tackling some of the many questions still open in this field, using one of our model systems. These questions include determining the magnitude of the chirality induced drift as a function of helix shape, using microprinted helices or flagella of different micro-organisms. Another possibility is to study the role of flexibility using the nano-ribbon helices on their transport in chosen microflows.

Required background of the student: Physics, if possible, Hydrodynamics, Complex fluids or Soft Matter. Taste for performing experiments is necessary and skills in microfabrication or microfluidics would be a plus.

A list of 5 (max.) representative publications of the group:

Chakrabarti, et al. Nature Physics 16 (6), 689-694
du Roure, et al Annual Review of Fluid Mechanics. 51:539
Pham, J. et al. Physical Review E, 92, 011004(R)
Liu et al. PNAS 115 (38) 9438-9443.
Cappello et al. Physical Review Fluids 4, 034202