# MPIDS Seminar



## **Micro- and nano-swimmers**

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Microorganisms such as bacteria, ciliates, green algae are often found in nature to swim in water. Their swimming seems to be similar to humans but it is quite different in a physical standpoint. They are in a regime of low-Reynolds-number fluid due to their tiny sizes implying viscosity of fluid is dominant over inertia and they are confronted in strong thermal fluctuations from fluid. In order to overcome random Brownian motions and achieve directionality, they have evolved special locomotion parts such as cilia or flagella with efficient propulsion mechanisms.

Bacteria such as E. coli or R. meliloti exploit multiple flagella of helical shapes for locomotion. The flagella are randomly attached to the cell body and rotated by flagella motors. In a swimming state, the flagella with slightly different rotational speeds self-organize into a bundle while they are disentangled in a tumbling state. To change swimming directions, E. coli reverses the directions of rotary motors and R. meliloti modulates the rotational speed. Here, one may ask intriguing questions. How are individual flagella synchronized to form a bundle? Why do bacteria have multiple flagella and what is the benefit for them? What is the role of hydrodynamic interactions for bacterial swimming and tumbling? I want to address these fundamental questions using advanced computer simulation techniques.

In further small scales, nano or angstrom scales, molecular motors such as kinesins and dyneins in cell which walk along microtubules or actin filaments to transport cargos such as lipid or proteins, and synthetic motors such as Janus motor, one half coated by catalytic and the other half coated by noncatalytic parts, are in similar physical circumstances as microorganisms. These motors, that convert chemical energy to mechanical work and take various propulsion mechanisms with the sources of chemicals, heat, electric fields, etc., self-propel, communicate with each other, and work together to accomplish a common goal.

Here, I want to address basic principles or underlying physics to explain the motors motions and hydrodynamics by taking continuum theory and microscopic particle-based simulations. I hope that comparison of two approaches and results provides a proper and deeper understanding of the nature of self-propelling motors, flow fields, hydrodynamic interactions, and eventually emergent collective behaviors of many motors.

#### References:

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[3] S. Palagi, A. G. Mark, S. Y. Reigh, K. Melde, T. Qiu, H. Zeng, C. Parmeggiani, D. Martella, A. S. Castillo, N. Kapernaum, F. Gießelmann, D. S. Wiersma, E. Lauga, and P. Fischer, Nature Mater.

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#### Friday, April 13<sup>th</sup>, 2018 at 09:30 am MPIDS, Prandtl lecture hall, Am Faßberg 11, Göttingen

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