AGjDPG 6: Biophysics II: Mechanics and Flow in Biological Systems (with BP)

Time: Thursday 10:30–11:30 Location: HSZ 201

Invited Talk AGjDPG 6.1 Thu 10:30 HSZ 201

The Hydrodynamics of Microswimmers — •Gerhard Gompper — Institut für Festkörperforschung and Institute of Advanced Simulations, Forschungszentrum Jülich, Jülich, Germany

Both in soft matter and in biology, there are numerous examples of swimmers and self-propelled particles. With a typical size in the range of a several micro-meters, both low-Reynolds-number hydrodynamics and thermal fluctuations are essential to determine their dynamics [1,2]. Prominent examples are sperm cells which are propelled by a snake-like motion of their tail, bacteria like *E. coli* which move forward by a rotational motion of their spiral-shaped flagella, and synthetic bimetallic nanorods.

We have studied the behavior of sperm cell and self-propelled rods by performing multi-particle collision dynamics (MPC) simulations, a particle-based mesoscale hydrodynamics technique which captures the hydrodynamic behavior of a wide range of complex fluids very well [3,4]. We focus here on the cooperative behavior of swimming sperm [5], and on the dynamic properties of individual sperm cells and nanorods near surfaces [6,7]. Both sperm cells and self-propelled rods display a strong surface excess in confined geometries. For rods, scaling laws for the dependence of the surface excess on the rod length and the propulsive force are derived [6].

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Invited Talk AGjDPG 6.2 Thu 11:00 HSZ 201

What sperm head wiggling can tell us about flagellar hydrodynamics — •B.M. Friedrich[1], I.H. Riedel-Kruse[3], J. Howard[4], and F. Julicher[2] — [1]Weizmann Institute of Science - Department of Materials and Interfaces, Rehovot, Israel — [2]Max-Planck-Institute for the Physics of Complex Systems, Dresden, Germany — [3]Stanford University, Stanford, USA — [4]Max Planck Institute of Molecular Cell Biology and Genetics, Dresden, Germany

Sperm cells propel themselves in a liquid by generating regular bending waves of their whip-like flagellum. At the relevant length and time scales of sperm swimming, inertia is negligible and self-propulsion is achieved purely by viscous forces. The shape of the flagellar beat determines the path along which a sperm cells swims.

To test a simple hydrodynamic theory of flagellar propulsion known as resistive force theory, we conducted high-precision measurements of the head and flagellum motions during circular swimming of bull spermatozoa near a surface. On short time-scales, the sperm head "wiggled" around an averaged path with the frequency of the flagellar beat. We found that the fine-structure of sperm swimming represented by this rapid wiggling is, to high accuracy, accounted for by resistive force theory and results from balancing forces and torques generated by the beating flagellum. By comparing experiment and theory, we could determine the hydrodynamic friction coefficients of the flagellum.

On time-scales longer than the flagellar beat cycle, sperm cells followed circular paths of non-zero curvature due to an asymmetry of their flagellar bending waves, in agreement with quantitative predictions of resistive force theory.

Finally, I will discuss how sperm cells can actively regulate the non-zero curvature of their swimming paths and address the relation to sperm navigation in a concentration gradient of a chemoattractant.

References J. Gray, G. T. Hancock, J. exp. Biol. 32 (1955). B.M. Friedrich, I.H. Riedel-Kruse, J. Howard, F. Julicher, J. exp. Biol. 213 (2010).