"Low Reynolds Number Swimmers"

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At low Reynolds number (Re << 1) simple reciprocal shape changes do not result in any net displacement of a swimmer in water. This limitation is known as the “scallop theorem”. Hence, asymmetric non-reciprocating complex actuation mechanisms are required for swimming. With this complication in mind, I will discuss experimental systems that we have developed that overcome kinematic reversibility and are effective in their locomotion at small scales. The survey will include: The smallest chemical Janus nanomotors that have been realized to date. These are comparable in size to a large enzyme and show that concepts of self-diffusiophoresis work down to the nanometer scale [1]. I will also discuss nanopropellers that are so small that they can move through the macromolecular network of biological tissue-like gels [2]. Finally, I will show that the complex hydrodynamics of non-Newtonian fluids presents an engineering opportunity as it allows simple symmetric microswimmers to be built and actuated [3] – swimmers that cannot move in water because of the “scallop theorem”.

[1] "Self-propelling nanomotors in the presence of strong Brownian forces", T.-C. Lee, M. Alarcón-Correa, C. Miksch, K. Hahn, J.G. Gibbs, P. Fischer, *Nano Lett*. **14**, 2407 (2014).

[2] “Nano-Propellers and their Actuation in Complex Viscoelastic Media”, D. Schamel, A.G. Mark, J.G. Gibb, C. Miksch, K.I. Morozov, A.M. Leshansky, P. Fischer, *ACS Nano* **8**, 8794 (2014).

[3] Swimming by Reciprocal Motion at Low Reynolds Number", T. Qiu, T.-C. Lee, A. G. Mark, K. I. Morozov, R. Münster, O. Mierka, S. Turek, A. M. Leshansky, P. Fischer, *Nature Comm*. **5** 5119 (2014).