Politecnico di Torino

Dipartimento di Scienze Matematiche "G. L. Lagrange"

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Multi-scale analysis and reduced models for low-Reynolds swimmers

Dr. Zoppello introduces the seminar.

Abstract

Over a long period of time, or from a distance, the motion of many swimmers can appear smooth, with their trajectories appearing almost ballistic. These long-time behaviours, however, often mask more complex dynamics, such as the side-to-side snakelike motion exhibited by spermatozoa as they swim, propelled by the frequent and periodic beating of their flagellum, or shape-changing microorganisms and microrobots. Many models of motion neglect, often without formal justification, these effects in favour of smoother long-term behaviours.

In this talk, I will present recent results based on multi-scale analysis and evaluating the long-term effects of high-frequency oscillations on translational and angular motion for various classical swimming models of micro-scale swimmers, with the purpose of assessing the relevance of neglecting these oscillations, and derive simplified equivalent models. In particular, I will focus on the celebrated Jeffery orbit model established in 1922, which can be, according to our results, surprisingly widely generalised to fast-shape-changing bodies. Finally, I will provide an interpretation of these reduced models in terms of "effective shapes".

This study was carried out with M. P. Dalwadi, B. J. Walker (UCL), E. A. Gaffney (U. Oxford) and K. Ishimoto (U. Kyoto).

Biography

Clément Moreau is currently a Postdoctoral Fellow of the Japan Society for the Promotion of Science, working at the Research Institute for Mathematical Sciences in Kyoto University since October 2020. He graduated from École Normale Supérieure de Cachan in 2017, and obtained his PhD in applied mathematics from Université Côte d'Azur in 2020. His research interests include mathematical control theory and optimisation, theoretical and computational fluid dynamics, modelling and applications to locomotion of biological and artificial swimmers at microscopic scale.