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Influence of yawing and other fast-timescale motion on low-Reynolds swimmers trajectories

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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, we will present recent results [1] evaluating the long-term effects on high-frequency oscillations on translational and angular motion, with the purpose of assessing the relevance of neglecting these oscillations, and derive simplified equivalent models.

In the case of a rigid oscillating body, using multiple-scales analysis, we identify and quantify biases induced on the speed and average direction of propulsion. In particular, when the swimmer is moving within a shear flow, we are able to show that the average motion is those of a Jeffery's orbit [2], with modified parameters explicitly defined with respect to the yawing motion. We then extend this generalised Jeffery's orbit to periodically shape-changing bodies, which is illustrated by displaying the "hydrodynamically equivalent" ellipsoid to simple oscillating filaments. This study is carried out in the context of microswimming, but the results are applicable to a variety of active particle models.

REFERENCES

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