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Optimal swimming of model ciliates SEBASTIEN MICHELIN, Ecole polytechnique - LadHyX, ERIC LAUGA, UCSD - MAE — In order to swim at low Reynolds numbers, microorganisms must undergo non-time-reversible shape changes. In ciliary locomotion, this symmetry breaking is achieved through the actuation of many flexible cilia distributed on the surface of the organism. Experimental studies have demonstrated the collective synchronization of neighboring cilia (metachronal waves), whose exact origin is still debated. Here we consider the hydrodynamic energetic cost of ciliary locomotion and consider an axisymmetric envelope model with prescribed tangential surface displacements. We show that the periodic strokes of this model ciliated swimmer that minimize the energy dissipation in the surrounding fluid achieve symmetry-breaking at the organism level through the propagation of wave patterns similar to metachronal waves. We analyze the properties of the optimal strokes, in particular the impact on the swimming performance introduced by a restriction on maximum cilia tip displacement due to the finite cilia length.

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