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Asynchronous beating of cilia enhances particle capture rate

YANG DING, Beijing Computational Science Research Center, EVA KANSO, University of Southern California — Many aquatic micro-organisms use beating cilia to generate feeding currents and capture particles in surrounding fluids. One of the capture strategies is to “catch up” with particles when a cilium is beating towards the overall flow direction (effective stroke) and intercept particles on the downstream side of the cilium. Here, we developed a 3D computational model of a cilia band with prescribed motion in a viscous fluid and calculated the trajectories of the particles with different sizes in the fluid. We found an optimal particle diameter that maximizes the capture rate. The flow field and particle motion indicate that the low capture rate of smaller particles is due to the laminar flow in the neighbor of the cilia, whereas larger particles have to move above the cilia tips to get advected downstream which decreases their capture rate. We then analyzed the effect of beating coordination between neighboring cilia on the capture rate. Interestingly, we found that asynchrony of the beating of the cilia can enhance the relative motion between a cilium and the particles near it and hence increase the capture rate.

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