Numerical Simulation of Auto-Propulsion Mechanism of Microorganism Inside a Microchannel

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Abstract

The maneuvers of appendage enabled bacteria displays a lot of intriguing fluid dynamic behavior in the viscosity dominated world, which has fascinated the researchers over the time. The study encompasses revolutionary analytical study of Taylor [1], classic experimental investigation of Rothschild [2], pioneering numerical simulation of Fauci [3] and many more. Till date, ample of surprising and enthralling results have been reported by different analytical and computational studies, supported by experimental investigations. Taking a step further, the present study demonstrates the several ground breaking flow phenomena arising out of hydrodynamic interactions between two microorganisms swimming inside a microchannel with close proximity. The results theorized in the present investigation scrutinizes the varying behavior of the bacteria while moving inside a micro-capillary at different Reynolds number (Re). At high Re, the two swimming microorganisms tend to lock at anti-phase configuration [Figure 1(a) - 1(b)]. While at low Re, an in-phase configuration [Figure 2(a) - 2(b)] is attained as a consequence of hydrodynamic interaction alone. Computational fluid dynamic framework with fluid structure interaction (FSI) interface is adopted for experimentation in which the motion of fluid (solid) is described in Eulerian (Lagrangian) framework. All the numerical computations are performed in COMSOL Multiphysics software. The self-propelling microorganism is assumed to be of structural part and the surrounding fluid is Newtonian and incompressible in nature. It is expected that the startling results obtained will augment the exploration of this mystery to a certain extent.

Reference

[1] GI Taylor , Analysis of swimming of microscopic organisms, Royal society of London Proceeding Series A, vol. 209, pp. 447–461 (1951).
[2] L. Rothschild , Non-random distribution of bull spermatozoa in a drop of sperm suspension, Nature, vol. 198, pp. 1221–2 (1963).
[3] L.J. Fauchi and C. S. Peskin , A computational model of aquatic animal locomotion, Journal of Computational Physics, vol. 77, pp. 85–108 (1988).

Figures used in the abstract

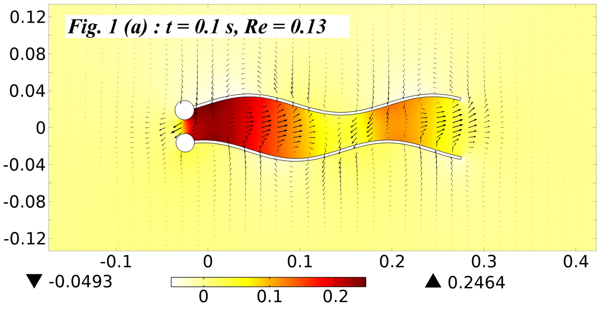

Figure 1

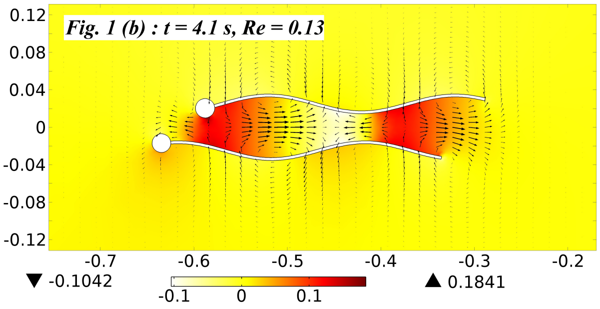

Figure 2

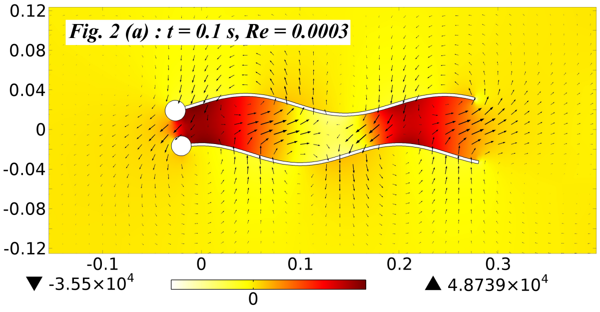

Figure 3

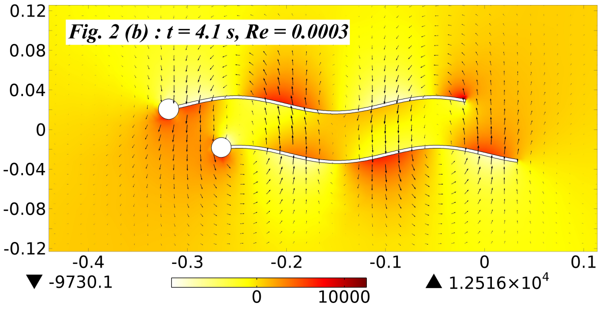
Fig. 2 (b) : t = 4.1 s, Re = 0.0003
0.12
0.08
0.04
0
-0.04
-0.08
-0.12
-0.4
-0.3
-0.2
-0.1
0
0.1
▼ -9730.1
0
10000
▲ 1.2516×10^4

Figure 4