Abstract Submitted
for the DFD16 Meeting of
The American Physical Society

Optimal control, optimization and asymptotic analysis of Purcell's microswimmer model OREN WIEZEL, YIZHAR OR, Technion, Israel Institute of Technology — Purcell's swimmer (1977) is a classic model of a three-link microswimmer that moves by performing periodic shape changes. Becker et al. (2003) showed that the swimmer's direction of net motion is reversed upon increasing the stroke amplitude of joint angles. Tam and Hosoi (2007) used numerical optimization in order to find optimal gaits for maximizing either net displacement or Lighthill's energetic efficiency. In our work, we analytically derive leading-order expressions as well as next-order corrections for both net displacement and energetic efficiency of Purcell's microswimmer. Using these expressions enables us to explicitly show the reversal in direction of motion, as well as obtaining an estimate for the optimal stroke amplitude. We also find the optimal swimmer's geometry for maximizing either displacement or energetic efficiency. Additionally, the gait optimization problem is revisited and analytically formulated as an optimal control system with only two state variables, which can be solved using Pontryagin's maximum principle. It can be shown that the optimal solution must follow a "singular arc". Numerical solution of the boundary value problem is obtained, which exactly reproduces Tam and Hosoi's optimal gait.

Oren Wiezel
Technion, Israel Institute of Technology

Date submitted: 28 Jul 2016 Electronic form version 1.4