THREE DIMENSIONAL MODELING OF A SUSPENSION OF SWIMMING MICROORGANISMS

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Under certain circumstances populations of swimming microorganisms (cells) can produce remarkable patterns. Although an individual cell's motion is simple, a large collection of individuals acting in concert can result in complicated macroscopic behavior for the overall suspension. These bioconvection patterns have been extensively studied [1], including formal analysis [2] [3], and numerical models [4] [5] [6]. The cells under consideration here are modeled after *Chlamydomonas Nivalis*, a biflagellar algal cell. They tend to swim upwards and are slightly more dense than the surrounding fluid. This results in an unstable configuration because of the suspension's density gradient. Eventually a transition takes place and cells coalesce into slightly heavier regions. These slightly heavier regions pull in more cells, increasing the local suspension density, until downwelling plumes are formed. Patterns are formed from these downwelling regions containing higher cell concentrations and the intervening less concentrated upwelling regions. The types of patterns, as well as their stability, is dependent on many system parameters (e.g., fluid height, cell concentration, cell swimming speed).

A mathematical model is presented for the motion and orientation of an individual discrete cell, including stochastic effects on swimming speed and orientation. The suspension equations are derived from fluid equations by including modifications due to the presence of the cells. The model equations are solved numerically, using a Galerkin finite element method for the continuum suspension, and time integrating the trajectories for each of the discrete cells. Because the number of physical cells is quite large we resort to using a smaller number of computational cells with appropriate weighting ratios. The dependence on problem parameters is investigated.

References

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