CENTER FOR FLUID MECHANICS
AND
THE FLUIDS, THERMAL AND CHEMICAL PROCESSES GROUP
OF
THE DIVISION OF ENGINEERING
SEMINAR SERIES

Michael D. Graham
Dept. of Chemical and Biological Engineering
Univ. of Wisconsin-Madison

Transport and Collective Dynamics in Suspensions of Swimming Microorganisms

A suspension of swimming organisms is an example of an "active" complex fluid. At the global scale, it has been suggested that swimming organisms such as krill can alter mixing in the oceans. At the laboratory scale, experiments with suspensions of swimming cells have revealed characteristic swirls and jets much larger than a single cell, as well as increased effective diffusivity of tracer particles. This enhanced diffusivity may have important consequences for how cells reach nutrients, as it indicates that the very act of swimming toward nutrients alters their distribution. The enhanced diffusivity has also been proposed as a scheme to improve transport in microfluidic devices and might be exploited in microfluidic cell culture of motile organisms or cells.

The feedback between the motion of swimming particles and the fluid flow generated by that motion is thus very important, but is as yet poorly understood. In this presentation we describe theory and simulations of hydrodynamically interacting microorganisms that shed some light on the observations. In the dilute limit, simple arguments reveal the dependence of swimmer and tracer velocities and diffusivities on concentration. As concentration increases, we show that cases exist in which the swimming motion generates dramatically enhanced transport in the fluid. This transport is coupled to the existence of long-range correlations of the fluid motion. Furthermore, the mode of swimming matters in a qualitative way: microorganisms pushed from behind by their flagella are predicted to exhibit enhanced transport and long-range correlations, while those pulled from the front are not. A physical argument supported by a mean field theory sheds light on the origin of these effects. These results imply that different types of swimmers have very different effects on the transport of nutrients or chemoattractants in their environment; this observation may be related to the evolution of different modes of swimming.

TUESDAY, MARCH 23, 2010

Barus & Holley, Room 190

4:00pm