RUI: Lagrangian studies of active mixing -- barriers, enhanced transport and collective behavior

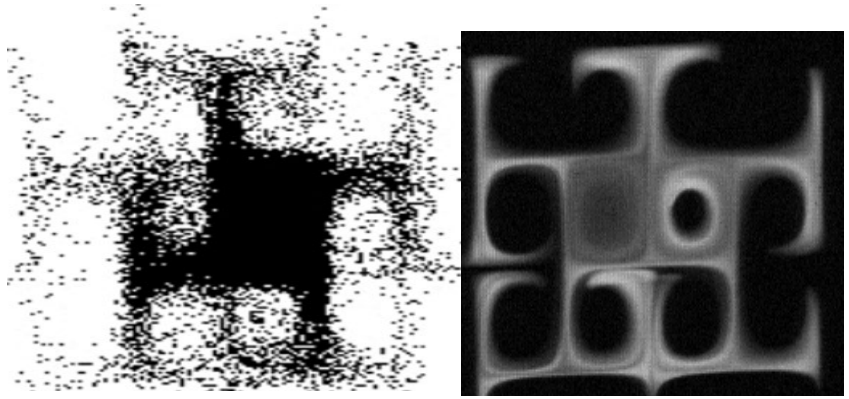
Thomas H. Solomon, Bucknell University

We are conducting experiments that explore how fluid flows affect the motion of swimming microbes in the fluid, analogous to the effects of oceanic flows on fish migrations or algae blooms. In this year:

- We obtained evidence of invisible barriers ("swimming invariant manifolds" or SwIMs) that block the motion of swimming microbes in fluid flows and provide a mechanism for long-range transport.
- Showed that the structures guiding the motion of microbes in a flow are almost identical to those for spreading reaction fronts in the same flow.
- Started experiments to create artificial microbe "blooms" in a well-controlled lab setting to elucidate the crucial role of fluid mixing on the process.

An important theme of this research is universality – the idea that the same theoretical approach can describe very different systems; here swimming microbes and reaction fronts.

SwIMs (in black) for a vortex array flow, along with a reaction front (orange) moving through.



(Left) Paths of swimming brine shrimp organisms moving through a vortex array flow. (Right) Reaction front moving through the same vortex array flow.

DMR-1806355

RUI: Lagrangian studies of active mixing -- barriers, enhanced transport and collective behavior

Thomas H. Solomon, Bucknell University

The results of these experiments may lead to a better understanding of a wide range of systems with important impacts on society, including (a) microfluidic chemical reactors and medical diagnostic devices, (b) self-assembled novel materials and micro-scale robots, (c) blooms of harmful algae in the oceans, and (d) the effects of moving populations on the spreading of a disease.

In the Spring of 2023, the PI for this grant taught an "Inside-Out" course in a local prison on "Science, Technology & Society." Half of the students in the course were Bucknell students and the other half were inmates of the prison. As part of the course, we discussed public funding of scientific research, including the NSF requirement that proposers consider "Broader Impacts" of our research. Pictures are not allowed of any activities in the prison, so the image section of this slide contains a sample of quotes from students in the course.

Sample reflections from inmates from Inside-Out course (pictures are not allowed in the prison)

"It is commonly said (amongst inmates) that when we first get home, we have a glow to us that others notice/comment on. Well during/after the introductory class I feel like I got a small taste of that glow. For those two and a half hours I didn't feel 'less than'. I felt like a regular person."

"I had no idea how I would feel, being in a room with 12 young people who were voluntarily in prison, because I didn't know how THEY'D feel. But they all seemed ok with us, which made me ok with them. … Being around others who love learning was refreshing."

(Related to discussion of "broader impacts" mandate for NSF proposals) "I think that scientists should consider long and hard the impacts both positive and negative of their research and breakthroughs. No, I am not asking them to be fortune tellers because that would be unfair. However, to whom much is given, much is expected."