

**Special Joint Condensed Matter
and Center for Soft Matter and
Biological Physics Seminar**

Prof. Chih-Kuan Tung

North Carolina A&T State University

“What Do Bull Sperm Know about Emergent Behaviors?”

Monday, April 8, 2019

4:00pm – 5:00pm

304 Robeson Hall

In a complex system, some patterns or orders only emerge when the objects interact with the environment or each other. In a dynamical system, the description of how the environmental stress induces the new order can often be described by a bifurcation. In a many-body system, the interaction between individual objects often results in a phase transition or phase separation. These are arguably the most universal descriptions you can find in physics, covering phenomena from Higgs mechanism in high energy, superconductivity in condensed matter, to thermal convection in nonlinear dynamics. Biology provides vast number of different complex systems, which provide a fertile ground to explore universality through their emergent behaviors. In this talk, I will focus on two emergent behaviors discovered by using microfluidics to model the physical environment of the mammalian female reproductive tract for sperm. By modeling the outward going fluid flow in the female tract, we showed that sperm swimming against a flow can be described by a bifurcation theory, such that the upstream orientation order only emerges when the flow rate exceeds a critical level, and the emergence follows a $\frac{1}{2}$ power law, which is known for a mean field theory. By adding polymer into the sperm medium to model the viscoelasticity naturally found in the mucus, we found that sperm start to form dynamic clusters, so that the cells dynamically join or dissociate from the clusters, similar to a liquid/gas phase separation. Further, by modeling the pulsatile flow generated by muscular contraction, we saw hundreds of sperm forming a large flock after the flow dissipated. Interestingly, the direction of the large flock can be either with or against the flow direction. I will discuss the implications in both physics and biology.



COLLEGE OF SCIENCE
PHYSICS
VIRGINIA TECH.