ASU Department of Physics
Arizona State University

COLLOQUIUM

Thursday, August 24, 2023

Refreshments at 3:15pm outside PSF 101
Colloquium from 3:30pm - 4:30pm in PSF 101

Exploring the 'Rules of Life' Through Optical Microscopy

Professor Douglas Shepherd

Arizona State University

Abstract:

One governing principle of the microscopic world is "predictable randomness," where a fluctuating process appears random, but the average outcome of the process is predictable. For example, a diffusing particle's movement appears random during Brownian motion, but the long-time distribution of the particle's displacement from its starting point is highly predictable. Going one step further, the fluctuation-dissipation theorem provides a framework to probe the local fluid environment's physics by connecting the particle's displacement to fluid drag.

An exciting frontier in biological physics is evaluating if predictable randomness extends to more complex, multi-component biophysical systems, such as active propulsion or genetic regulation. Taking a statistical physics approach to such complex molecular systems may lead to the discovery of predictive models and new insights into how the rules of life interplay with the laws of physics. One of the first steps toward discovering underlying physical models of complex, dynamic biophysical systems is advancing the current state of the art in optical microscopy and computational imaging. More concretely, existing microscopy approaches do not have sufficient space-time bandwidth to accurately and robustly quantify fluctuations in the dynamic environment of living cells.

In this talk, I will introduce the fundamentals of quantitative optical imaging of microscopic fluctuations across spatio-temporal scales and the inverse problem frameworks used to extract physical insight from such measured fluctuations. I will discuss our recent results on directly measuring the propulsion efficiency for a biological microscale propeller (the E. coli flagella) by combining a new approach to 3D fluorescence imaging with the fluctuation-dissipation theorem. I will conclude with our recent efforts in developing "Fourier Synthesis" optical diffraction tomography, a potential pathway to nanoscale 3D imaging at volume rates above 1 kilohertz.

Biography:

Douglas Shepherd is an assistant professor in the Department of Physics and the Center for Biological Physics. He directs the Quantitative Imaging and Inference Laboratory (qi2lab). The qi2lab develops and applies quantitative imaging methods to understand self-organization and cellular “decision-making” in the context of the physical laws and principles that govern the microscopic world. He obtained his undergraduate degree in Physics from the University of California Santa Barbara and his doctoral degree in Physics from Colorado State University. He completed a postdoctoral fellowship at the Center for Nonlinear Studies and the Center for Integrated Nanotechnologies at Los Alamos National Laboratory. In 2013, he joined the University of Colorado Anschutz Medical Campus faculty, and in 2019, he and qi2lab moved to ASU.

Host: Prof. Rizal Hariadi
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