BIOGRAPHICAL SKETCH

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NAME: Michael O'Brien

eRA COMMONS USER NAME (credential, e.g., agency login): N/A

POSITION TITLE: PhD Candidate

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
New York University, New York NY	B.A.	05/2020	Physics
Harvard University, Cambridge MA	Ph.D.	05/2027	Physics

A. Personal Statement

I am interested in understanding how the cytoskeleton assembles structures of interacting filaments to carry out coordinated, robust cellular function. In particular, the spindle is an assembly of microtubules, molecular motors, and crosslinkers that orchestrates cell-division by dividing genetic material into both daughter cells. As a statistical physicist, I'd like to build a picture of both the self-assembly and dynamics of the spindle across length scales. The physics of how interactions between individual microtubules by molecular motors gives rise to these structures and their remarkable properties such as error-correction and self-healing is not well understood. The spindle is a fascinating example of active matter, which is the study of many interacting components that consume energy locally. For this reason, active matter is fundamentally out of equilibrium, and the tools of statistical mechanics can provide insight.

During my Ph.D., I am also interested in developing novel techniques for analysis of cryo-EM data to use for statistical mechanics. We cannot rely on traditional cryo-EM analysis that reconstructs high-resolution biological structure. Rather, we need to extract population statistics of our proteins in noisy, crowded environments. This will require the development of a novel framework for Bayesian statistical inference of the properties of microtubules and molecular motors and associated computational tools. With my experience developing several different software packages, I am looking forward to developing these tools and making them accessible to the EM community.

My Ph.D. work excellently combines my theoretical interest in non-equilibrium statistical mechanics and my experimental and computational interests in statistical inference and open-source software development. I am fully equipped and have the motivation to carry out the proposed research project. This work focuses on initial steps in understanding the human cell from the bottom-up, rather than the traditional means of analyzing collective behavior from the top-down using light microscopy. This has the potential, in the far future, to revolutionize the way we develop drugs and medical technology by developing a rigorous understanding of cellular function.

B. Positions, Scientific Appointments, and Honors

2021-Present	Ph.D. Candidate, Department of Physics, Harvard University, Cambridge MA
2020-2021	Associate Research Analyst, Center for Computational Biology, Flatiron Institute, New York, NY
2016-2020	Research Assistant, Center for Soft Matter Research, New York University, New York, NY

C. Contributions to Science

1. During my undergraduate at New York University, I worked in Dr. David Grier's soft-condensed matter research group. During this time, I focused on developing microscopy software for real-time, interactive micromanipulation of colloids using holographic optical tweezers. Using these software tools and the lab's novel technique of three-dimensional particle tracking, I performed experiments demonstrating the challenges of using traditional holographic optical tweezers for precision assembly of three-dimensional colloidal quasicrystals. I served as the first author on this study. During this time, I also assisted on a publication that explored the use of machine learning to replace traditional particle localization algorithms in holographic video microscopy.
    a. O'Brien, Michael J., and David G. Grier. "Above and beyond: holographic tracking of axial displacements in holographic optical tweezers." *Optics Express* 27.18 (2019): 25375-25383.
    b. Hannel, Mark D., et al. "Machine-learning techniques for fast and accurate feature localization in holograms of colloidal particles." *Optics express* 26.12 (2018): 15221-15231.
2. Before starting my Ph.D., I spent a year in the Biophysical Modeling group in the Center for Computational Biology at the Flatiron Institute. Here, I continue to work jointly with a group in the Center for Computation Astrophysics to develop statistical methods for analyzing the emergence of collection motion in simulations of swimming bacteria. We are currently working to produce a publication where I will serve as first author. Additionally, during my time there I completed a first author publication that used related statistics to study non-gaussianity in simulations of turbulent gas.
    a. O'Brien, Michael J., Blakesley Burkhart, and Michael J. Shelley. "Studying Interstellar Turbulence Driving Scales Using the Bispectrum." *The Astrophysical Journal* 930.2 (2022): 149.