BIOGRAPHICAL SKETCH

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NAME: Dasbiswas, Kinjal

eRA COMMONS USER NAME (credential, e.g., agency login): kdasbiswas

POSITION TITLE: Assistant Professor

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)	END DATE MM/YYYY	FIELD OF STUDY
Indian Institute of Technology, Kanpur	M.Sc.	05/2007	Physics
University of Florida	Ph.D.	08/2012	Physics
Weizmann Institute of Science	Postdoctoral Fellow	10/2015	Biophysics
University of Chicago	Postdoctoral Scholar	08/2018	Biophysics

A. Personal Statement

I am an assistant professor in Physics at the University of California in Merced. My research interests and contributions span the emerging fields of mechanobiology and active matter, which I work to bridge through theoretical insights. To this end, I have both developed new physical theory inspired by biological matter, as well as modeled and explained experimental results in biophysics and soft material science. My graduate training in condensed matter physics theory has given me the necessary quantitative tools required to model biological matter, and my subsequent interdisciplinary postdoctoral training enables me to bring a soft matter-based approaches to cell biology and biomaterials research.

My current research group includes four predoctoral students, of whom three are qualified PhD candidates, and two undergraduate student researchers. I also mentored two postdoctoral researchers before this, who found employment subsequently at University of Dusseldorf and University of Pennsylvania. Before starting my own research group, I helped mentor a diverse group of graduate and undergraduate students working on interdisciplinary subjects at the interface of biological and physical sciences at two institutions (University of Chicago and Weizmann Institute) during my postdoctoral work. At UC Merced, I am a member of the NSF-CREST Center for Cellular and Biomolecular Machines and actively participate in their mentoring and outreach activities. I mentored the research projects of three undergraduate students who were recruited with CCBM support. I also designed and teach a graduate level course on “Computation and Modeling in Biophysics” as part of the training of the Center’s graduate fellows. Additionally, I am a member of the graduate admissions committee and the undergraduate recruitment committees for the Physics department at UC Merced.

An ongoing project that I would like to highlight:

NSF-BMMB-2138672
Dasbiswas (PI)
05/15/22-05/15/24
ERI: Multi-Scale Modeling of Cell-Matrix Mechanical Interactions in Endothelial Cell Network Assembly

Since joining UC Merced in 2018, I have co-authored fourteen research articles. As PI and senior author, I published seven peer-reviewed journal articles with my students or postdocs. I also developed and maintain active collaborations with four different experimental laboratories working on cell biology and cytoskeletal proteins. I strongly believe that I have the necessary scientific expertise and management skills required to lead this collaborative project.

B. Positions and Honors

Positions and Employment

2018 - now Assistant Professor, University of California, Merced

2015 - 2018 Postdoctoral Researcher, James Franck Institute, University of Chicago
2012 - 2015 Postdoctoral Fellow, Weizmann Institute of Science, Israel

Other Experience and Professional Memberships

2015 – now Member, Biophysical Society, and Mechanobiology subgroup
2009 - 2012 Member, American Physical Society
2016 – now Member, American Physical Society and Division for Biological Physics subgroup
2019 Panelist, Conference for Undergraduate Women in Physics (UC Santa Barbara)

2018 - now Member, NSF-CREST Center for Cellular and Biomolecular Machines

2022 -now Member, NSF-STC Center for Engineering Mechanobiology

Honors

2007-2008 Alumni fellowship, University of Florida for beginning graduate students
2012 E. Raymond Andrew Memorial Award, Department of Physics, University of Florida
2013 - 2015 PBC postdoctoral fellowship by VATAT (Israel Council of Higher Education)

C. Contribution to Science

Cell cytoskeletal structural order and function through mechanical forces

Cellular processes require tight spatiotemporal organization for effective outcomes. An example is the precisely ordered positioning of actin and myosin units required for muscle contraction. While a variety of specific biochemical interactions is certainly involved, recent experiments suggest that mechanical forces are crucial to the maintenance of these structures. My **r**ecent joint theory-experiment investigations with collaborators reveal that cell mechanical forces are important for ordered organization of the cytoskeleton, which in turn is crucial for cell function such as the coordinated contraction of heart muscle cells. Based on a coarse-grained model of the mechanical interactions between the cell's force-generating actomyosin units, I have developed, in a series of papers with experimental collaborators, which appeared in prestigious journals such as *Nature Communications* and *Nature Cell Biology*, a unified picture for structural order in the cytoskeleton of non-muscle as well as muscle cells driven by molecular motor-generated mechanical forces. I summarized these results on myosin organization in a review article published in the *Philosophical Transactions of the Royal Society B* in 2018 with my collaborators at the Mechanobiology Institute, National University of Singapore. Our physical theory then provides a unified picture of cytoskeletal ordering in different cell types (reviewed in Phil. Trans., 2018).

Since starting an independent position at UC Merced, I developed a physical model with my collaborators that explains the kinetics of formation of ordered structures of myosin motors. This is a significant advance over my earlier postdoctoral work, which was a purely static theory, in that it predicted only the ordered state as a balanced equilibrium configuration. Now, by theorizing that ordered structures are created through the force-driven restructuring of the cytoskeleton, we can predict the timescales for the kinetics of such ordering. The estimated timescale of tens of minutes matches closely with our analysis of actomyosin movements from microscopy images. I was the first and corresponding author of an article in the *Biophysical Journal* based on this work. Based on this theory, I am now developing a discrete elastic fiber network model for the cytoskeleton with my graduate student, Abhinav Kumar. Such modeling captures the nonlinear elastic properties of the cytoskeleton and will show how myosin motors interact mechanically at large distances through the forces they generate. I expect more such ordered subcellular and cytoskeletal structures to be identified given recent major advances in super-resolution microscopy, which my lab will investigate with experimental collaborators (Bershadsky lab, MBI Singapore and Gardel lab, University of Chicago).

a. Substrate stiffness-modulated registry phase correlations in cardiomyocytes maps structural order to coherent beating" by K. Dasbiswas, S. Majkut, D. E. Discher, S. A. Safran, *Nature Communications* 6, 6085 (2015).

b. Long range self-organization of cytoskeletal myosin-II filament stacks by S. Hu, K. Dasbiswas, Z. Guo, Y.-H. Tee, V. Thiagarajan, P. Hersen, T.-L. Chew, S. A. Safran, R. Zaidel-Bar and A. D. Bershadsky, *Nature Cell Biology* 19, 133 (2017).

c. Ordering of myosin II filaments driven by mechanical forces: experiments and theory by K. Dasbiswas, S. Hu, F. Schnorrer, S. A. Safran and A. D. Bershadsky, review article Phil. Trans. R. Soc. B 373: 20170114 (2018).

d. Registry kinetics of myosin motor stacks driven by mechanical force-induced actin turnover by K Dasbiswas, S Hu, AD Bershadsky and SA Safran. *Biophysical journal* 117 (5), 856-866 (2019).

Self-organization of cytoskeletal filament-motor aggregates

Liquid phase separation has been identified as a strategy employed by cells to compartmentalize their functions. Recent experiments by my collaborator, the Weirich lab at Clemson University (previously, at the Gardel lab at the University of Chicago) show that actin filaments in vitro may organize into liquid crystal droplets that grow and divide (when motorized) in a manner evocative of cell-division. In our collaborative papers, I proposed the idea that clusters of motors, modeled as colloidal inclusions in a biological liquid crystal, may spatially localize in and deform the actin droplet through their aligning interactions with ordered actin filaments. More recently, Fabian Jan Schwarzendahl, a former postdoc in my group, and I have developed a theoretical model for the self-organization of motors when confined to a droplet of filaments that they actively move. This posits an alternative hypothesis for the observations made by Weirich, that motor self-organization is based on their active transport of filaments according to their polarity, while moving themselves in the opposite direction, to ultimately find a central position between filaments of opposite polarity

Besides serving as models for division of synthetic or protocells, this joint theory-experiment research combines two exciting themes in the self-organzation of biological active matter: the effect of active mechanical forces in a confined droplet system, and the realization of a feedback between the spatial localization of the active force-generators (myosin motors) and the material medium (actin filaments) they deform or move. In fact, this latter idea is a crucial element of the recent hydrodynamic model that I have developed to describe active nematic lanes of gliding microtubules (another cytoskeletal filament) driven by kinesin motors diffusing on a fluid surface, seen by our collaborators at the Hirst lab (UC Merced Physics).

a. “Liquid behavior of cross-linked actin bundle”s by K. L.Weirich, S. Banerjee, K. Dasbiswas, T. A. Witten, S. Vaikuntanathan and M. L. Gardel PNAS 114(9), 2131-2136 (2017).

b. “Self-organizing motors divide active liquid droplets" by K. L. Weirich, K. Dasbiswas, T. A. Witten, S. Vaikuntanathan and M. L. Gardel PNAS 116(23), 11125-11130 (2019).

c. 4. “Tuning shape and internal structure of protein droplets via biopolymer filaments" by D. R. Scheff, K. L. Weirich, K. Dasbiswas, A. Patel, S. Vaikuntanathan and M. L. Gardel. *Soft Matter* 16, 5659 (2020).

d. 5. “Self-organization and shape change by active polarization in nematic droplets” by F. J. Schwarzendahl, P. Ronceray, K. L. Weirich and K. Dasbiswas. *Physical Review Research* 3, 043061 (2021).

Mechanochemical models for tissue patterning and shape change

A remarkable aspect of developing tissue is the controlled and orchestrated way in which the various pattern-forming processes are executed. These morphogenetic events have usually been identified with biochemical signaling pathways, where well-controlled gradients of molecular messengers called morphogens help define the basic body plan of a multicellular organism. However, morphogenetic events are also inherently mechanical: they usually cause changes in the shape of cells and of tissue structure, and therefore must involve forces and flows. In particular, cells can elastically interact with each other through the deformation of the surrounding extra-cellular matrix, or by directly pulling on each other through their contacts, by cytoskeletal forces generated by actomyosin contractility. Such elastic interactions are long-ranged, travel faster than chemical diffusion, and could facilitate global effects in the pattern forming process. We have shown theoretically that an interplay of

chemical diffusion and elastic interactions between force dipoles can lead to long-range mechanochemical gradients that scale with tissue size. This may explain the observed tendency for scaling in development, where embryos maintain their proportions over variations in their size within a good degree of accuracy.
My recent contribution with postdoctoral scientist Andrei Zakharov focuses on the deformations of thin elastic sheets inspired by epithelial cell monolayers whose coordinated shape changes are responsible for the morphogenesis of developing embryos. It is well-known in soft matter that thin elastic sheets are difficult to stretch but that they bend easily – leading to a rich array of 3D shapes that arise from the buckling of sheets driven by an imbalance of forces in plane – which is often harnessed in materials engineering to create shape-shifting structures for various applications. Such forces in the biological context arise from the contractility actively generated by myosin motors – which is regulated by chemical gradients, which in turn can be influenced by tissue deformation. As proof-of-concept, we considered two specific models – one where tissue curvature induced the production of chemicals that suppressed myosin contractility and another, where the local in-plane strain affected the binding rates of myosin. Both model assumptions led to long-range mechano-chemical patterns that propagated in time from an initial disturbance even without any diffusive or advective transport of the chemicals. These results were recently published in *Soft Matter* and in a special issue of the *European Physical Journal E* on computation in biological physics. We are currently pursuing the shapes that can result if the chemical concentration gradient can polarize the tissue sheets so that they develop an anisotropy in their contractility.

a. "Mechanobiological induction of long-range contractility by diffusing biomolecules and size scaling in cell assemblies" by K. Dasbiswas, E. Alster and S. A.Safran, *Scientific Reports* 6, 27692 (2016).

b. "Theory of epithelial cell shape transitions induced by mechanoactive chemical gradients" by K. Dasbiswas, E. Hannezo and N. S. Gov. *Biophys. J.* 114 (4), 968-977 (2018).

c. "Mechanochemical induction of wrinkling morphogenesis on elastic shells" by A.Zakharov and K. Dasbiswas. *Soft Matter* 17, 4738-4750 (2021).

d. "Modeling mechanochemical pattern formation in elastic sheets of biological matter" by A. Zakharov and K. Dasbiswas, *Eur. Phys. J. E* 44:82 (2021).

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https://scholar.google.com/citations?hl=en&user=3CEBwJgAAAAJ