Center for Soft Matter and Biological

Physics Discussion Meeting

Prof. Sohan Kale

(Mechanical Engineering, Virginia Tech)

"From Active-gel Theory of Actomyosin Cortex to Dynamic Vertex Models of Epithelial Mechanics"

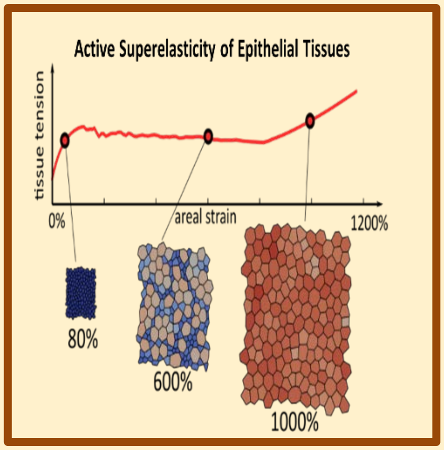
Date/Time: Friday, 13 November 2020,

_4:00pm -5:00pm_

Virtual Zoom

Zoom Link: https://virginiatech.zoom.us/j/83447279160

Abstract: Epithelial tissues are cohesive cellular sheets of adherent cells that line organs surface and cavities in our bodies. These bio-interfaces act as physical barriers against pathogens, regulate chemical transport, and compartmentalize our bodies into different functional units. Epithelial sheets maintain their mechanical integrity under dynamic conditions with mechanical loading of varied magnitudes and at wide range of loading rates. Moreover, various morphogenetic modules have revealed that epithelia can be shaped into functional 3D structures under the action of active internal and passive external forces. At intermediate timescales of seconds to minutes, epithelial mechanics is governed by the architecture and dynamics of cytoskeletal structures, especially by the active-viscoelastic rheology of the actomyosin cortex. Even in this seemingly simple regime with frozen junctional network, a rich phenomenology of epithelial behaviors governed by cortical dynamics has been recently discovered. Yet, a connection between cortical rheology and theoretical tissue-scale models of epithelia has been lacking. For instance, in vertex models of epithelial, phenomenological work functions governing the vertex dynamics are used that often lack a direct connection to the dynamic subcellular processes. We address this gap through a formulation based on Onsager's variational principle which allows us to coarse-grain active-gel models of the actomyosin cortex to tissue-scale vertex models. The tissue-scale rheology naturally emerges from the coupling between cell shapes and activity, viscoelasticity, and turnover of the cortex. This modeling approach provides a unifying framework to capture epithelial phenomenologies at different loading rates, including 'reinforcement' and 'fluidization' responses following sudden stretch and unstretch, solid and complex-fluid creep responses, transient flattening and stable folding of compression-induced folds in suspended epithelial sheets, pulsatile cellular oscillations, and active-superelasticity. While encapsulating these epithelial phenomenologies, the formulation also provides a common subcellular origin for seemingly disconnected tissue-scale behaviors.



Dr. Sohan Kale is an Assistant Professor in the Department of Mechanical Engineering at Virginia Tech. The overarching theme of the research in his 'Mechanics of Living Materials Lab' is to develop robust and high-fidelity models for complex bio-chemo-mechanical cellular and multicellular behaviors relevant in physiology, pathological conditions, and bioengineering applications. The research employs diverse set of topics and techniques from computational mechanics, soft matter ,non-equilibrium processes, inverse problems, and homogenization. Dr. Kale received his MS and PhD in Mechanical Engineering from University of Illinois at Urbana-Champaign in 2017. Following that, he was a postdoctoral scholar at UPC-Barcelona in the Mathematical and Computational Modeling (Lacan) group. He is a recipient of the Outstanding Dissertation Award from the Mechanical Engineering department and Mavis Future Faculty Fellow award from the college of engineering at UIUC.

Hosted by: Prof. Uwe Täuber, Physics, Virginia Tech