Modeling Stress Fiber Formation and Homeostasis

Valentin Wössner*[1,2], Lukas Riedel[3,4], Dominic Kempf[4], Falko Ziebert[1,2], Peter Bastian[4], and Ulrich S. Schwarz[1,2,4]

[1]Institute for Theoretical Physics, Heidelberg University – Germany
[2]BioQuant, Heidelberg University – Germany
[3]Department of Environmental Systems Science, ETH Zurich – Switzerland
[4]Interdisciplinary Center for Scientific Computing, Heidelberg University – Germany

Abstract

Stress fibers are contractile bundles of actin filaments found in the cytoskeleton of eukaryotic cells. They play crucial roles in force generation, mechanical adaptation, shape control and mechanosensing. Because they span larger regions of the cell, but at the same time are anchored in the cytoskeleton along their whole length, they act as integrators for cell mechanics. To efficiently incorporate stress fibers in whole cell models, we adopt a finite element approach for fiber-reinforced composites, describing single fibers as one-dimensional beams embedded into a two- or three-dimensional bulk medium, reduces computing time and allows for simulating different fiber configurations containing many fibers without the necessity of remeshing. Because the molecular details of stress fiber growth and maintenance are poorly understood and in addition depend on cell type, we explore more general principles of stress fiber positioning, e.g. their role in protecting cells from mechanical damage. Finally, we extend the finite element framework to also describe biochemical and mechanosensitive feedback.

*Speaker