A viscous active shell theory of the cell cortex

Hudson Borja Da Rocha*[1,2], Jérémy Bleyer[3], and Hervé Turlier[4]

[1]Department of Civil and Environmental Engineering, Massachusetts Institute of Technology – United States

[2]Department of Mechanical Engineering, Massachusetts Institute of Technology – United States

[3]Laboratoire Navier – ENPC, Université Gustave Eiffel, CNRS (UMR 8205) – France

[4]Center for Interdisciplinary Research in Biology – Collège de France – France

Abstract

The cell cortex is a thin layer beneath the plasma membrane that gives animal cells mechanical resistance. It drives most of their shape changes, from migration and division to multicellular morphogenesis. Constantly stirred by myosin motors and under fast renewal, the cell cortex may be well described by viscous and contractile active-gel theories. Under these assumptions, we performed rigorous dimensional reduction to derive constitutive equations for the mechanics of an effective surface with active myosin contractility and active polymerization, which extends previous descriptions of thin viscous layers. We showed that stresses and bending resultants would depend not only on the local metric (usually the case for elastic shells) but also on the curvature tensor. In our modeling, we also accounted for the fact that fast polymerization and depolymerization of actin filaments (turnover) actively regulate the thickness of the cell cortex. We showed that such turnover dynamics create active contributions to the surface mechanics (i.e., tension and bending moments), which have been previously overlooked. The ensuing model predicts that active cell deformations depend not only on the contractile activity of myosin motors but also on the speed of actin (de)polymerization, which is particularly essential to relate cell shape changes with its molecular regulation.

*Speaker