Cell Cytoskeleton Dynamics: Mechano-Sensing Properties

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Abstract

The actin cytoskeleton network is the dominant structure of eukaryotic cells. It is highly dynamic and plays a central role in a wide range of mechanical and biological functions. Cytoskeleton is composed mainly of actin filaments (F-actin) resulting from the self-assembly of monomeric actin (G-actin) and cross-linked by actin cross-linking proteins (ACPs) whose nature and concentration determine the morphological and rheological properties of the network. These actin filaments are reversibly coupled to membrane proteins (critical to the response of cells to external stress) and in conjunction with motor proteins from the myosin family, are able to generate contractile force during cell migration. Knowledge of actin cytoskeleton and its rheological properties is therefore indispensable for understanding the underlying mechanics and various biological processes of cells. Here, we present a 3-D Brownian dynamics (BD) computational model in which actin monomers polymerize and become cross-linked by two types of ACPs, forming either parallel filament bundles or orthogonal networks. Also, the active and dynamic behaviour of motors is included. In this simulation, actin monomers, filaments, ACPs, and motors experience thermal motion and interact with each other with binding probabilities and defined potentials. Displacements are governed by the Langevin equation, and positions of all elements are updated using the Euler integration scheme.

In this first part of the work, the mechano-sensing properties of active networks are investigated by evaluating stress and strain rate in response to different substrate stiffness.