Stochastic Dynamics of Clusters of Biomolecular Bonds

by

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Abstract:

Cohesion in biological systems is provided by a multitude of biomolecular bonds, including the receptor-ligand bonds connecting cells to their environment. Because typical binding energies are in the range of thermal energy, these bonds continuously open and close. This basic physical property of biological systems makes their structure very dynamic and allows cells to quickly change their organization, e.g. in response to external stimuli. It also implies that physical stability can only be achieved by clusters of bonds, for which some bonds can open while the others keep physical integrity. In many situations of interest, these processes are strongly modulated by external forces acting on the bond cluster, leading to non-linear effects due to load sharing between the different bonds. For small clusters, stochastic effects are highly relevant, resulting in noisy trajectories and the possibility of stochastic failure. The natural mathematical framework to describe the stochastic dynamics of bond clusters is the master equation. We will discuss several important biological examples in the context of cell adhesion which can be investigated with this approach. We will first discuss the stability of stationary adhesion clusters under force. Next we will address the stability of adhesion cluster at a moving interface in the context of retrograde flow. Finally we will address the role of cluster size for force generation by small ensembles of molecular motors.

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