Model for the Dynamics of the Cytoskeleton

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Particle tracking of microbeads attached to the cytoskeleton (CSK) reveals an intermittent dynamic. The mean squared displacement (MSD) is subdiffusive for small Δt and superdiffusive for large Δt, which are associated with periods of traps and periods of jumps respectively. The analysis of the displacements has shown a non-Gaussian behavior, what is indicative of an active motion, classifying the cells as a far from equilibrium material. Using Langevin dynamics, we reconstruct the dynamic of the CSK. The model is based on the bundles of actin filaments that link themself with the bead RGD coating, trapping it in an harmonic potential. We consider a one-dimensional motion of a particle, neglecting inertial effects (over-damped Langevin dynamics). The resultant force is decomposed in friction force, elastic force and random force, which is used as white noise representing the effect due to molecular agitation. These description until now shows a static situation where the bead performed a random walk in an elastic potential. In order to modeling the active remodeling of the CSK, we vary the equilibrium position of the potential. Inserting a motion in the well center, we change the equilibrium position linearly with time with constant velocity. The result found exhibits a MSD versus time τ with three regimes. The first regime is when $\tau < \tau_0$, where τ_0 is the relaxation time, representing the thermal motion. At this regime the particle can diffuse freely. The second regime is a plateau, $\tau_0 < \tau < \tau_1$, representing the particle caged in the potential. Here, τ_1 is a characteristic time that limit the confinement period. And the third regime, $\tau > \tau_1$, is when the particles are in the superdiffusive behavior. This is where most of the experiments are performed, under 20 frames per second (FPS), thus there is no experimental evidence that support the first regime. We are currently performing experiments with high frequency, up to 100 FPS, attempting to visualize this diffusive behavior. Beside the first regime, our simple model can reproduce MSD curves similar to what has been found experimentally, which can be helpful to understanding CSK structure and properties.

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