Spatially Inhomogeneous Search Strategies for Intracellular Transport: A Random Velocity Model

Anne Hafner[1] and Heiko Rieger[1]

[1]*Theoretical Physics, Saarland University, Saarbrücken, Germany*

Intracellular transport is vital for the proper functioning and survival of a cell. Cargo (proteins, vesicles, organelles, etc.) is transferred from its place of creation to its target locations via molecular motor assisted transport along cytoskeletal filaments. The transport efficiency is strongly affected by the spatial organization of the cytoskeleton, which constitutes an inhomogeneous, complex network. In cells with a centrosome microtubules grow radially from the central microtubule organizing center towards the cell periphery whereas actin filaments form a dense meshwork, the actin cortex, underneath the cell membrane with a broad range of orientations. The emerging ballistic motion along filaments is frequently interrupted due to constricting intersection nodes or cycles of detachment and reattachment processes in the crowded cytoplasm. In order to investigate the efficiency of search strategies established by the cell's specific spatial organization of the cytoskeleton we formulate a random velocity model with intermittent arrest states. With extensive computer simulations we analyze the dependence of the mean first passage times for different search problems on the structural characteristics of the cytoskeleton, the motor properties and the fraction of time spent in each state of motility. We find that a cell can optimize the search of narrow membranous targets by convenient alterations of the spatial organization of the cytoskeleton. An inhomogeneous network with a thin actin cortex constitutes an efficient intracellular search strategy.