Trapping in and escape time from tree-like structures of neuronal dendrites

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The branching morphology of neuronal dendrites in advanced nervous systems allows the neuron to interact simultaneously with several neighbors and additionally controls the transmission time of signals. Although it is expected that alterations in dendritic morphology induced by neurodegenerative disorders or aging directly influence the neural functions, it is not yet clear how transport properties of signals are affected by changes in key geometrical parameters. We present a model for stochastic transport inside dendritic trees and obtain exact analytical expressions for escape times from such complex structures, which identify the contributions of the extent of the tree, the bias induced by hierarchical variations of branch diameter, and the adsorption probability at biochemical cages. The analytical predictions are in remarkable agreement with simulation results. We moreover study how presence of disorder in the structure influences the first passage time statistics, and verify that volume exclusion does not affect the exponential nature of the tail behavior of the escape time distribution.