The narrow escape problem in a circular domain with radial piecewise constant diffusivity

M. Mangeat[1] and H. Rieger[1]

[1]*Center for Biophysics & Department for Theoretical Physics, Saarland University, 66123 Saarbrücken, Germany*

The stochastic motion of particles in living cells is often spatially inhomogeneous with a higher effective diffusivity in a region close to the cell boundary due to active transport along actin filaments [1]. As a first step to understand the consequence of the existence of two compartments with different diffusion constant for stochastic search problems we consider a Brownian particle in a circular domain with different diffusion constants in the inner and the outer shell. We focus on the narrow escape problem and compute the mean first passage time (MFPT) for Brownian particles starting at some predefined position to find a small region on the outer reflecting boundary. The asymptotic expression of the MFPT are obtained following [2].

For the annulus geometry we find that the MFPT can be minimized for a specific value of the width of the outer shell. In contrast for the two-shell geometry we show that the MFPT depends monotonously on the outer shell width. Then, the MFPT can be optimized only when a mechanism enforce the particle to stay close to the surface (e. g. [1,3]). Moreover we find that the distance between the starting point and the narrow escape region which maximizes the MFPT depends discontinuously on the ratio between inner and outer diffusivity.

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