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Feller Diffusion in an Interval: Inhomogeneous Fluctuation-Induced Asymmetric Escapes

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We investigate the escape properties of a Feller diffusion process confined to a finite interval within an exactly solvable framework. The dynamics correspond to a particle in a shifted harmonic potential with state-dependent diffusivity, which lifts the symmetry of the escape events. By assigning the boundaries as extinction (near-zero, fluctuation-suppressed) and outbreak (enhanced-noise) states, we demonstrate that spatial heterogeneity in fluctuations alters both the mean escape rate and the splitting probabilities. Moreover, even from unbiased initial conditions, suppressed fluctuations near the extinction boundary bias trajectories toward the outbreak state. The mean exit time exhibits a non-monotonic dependence on the initial position and the location of the potential minimum, attaining a maximum when the particle is initialized toward the low-noise boundary. The condition of maximum exit time is then nicely corroborated with the least coefficient of variance (CV), which is the hallmark for a stochastic escape from an interval. Depending on the relative values of the drift-to-noise strength and the initial spatial bias, fluctuations in exit time may dominate over its mean or vice versa. Therefore, we further explored the effect of stochastic resetting on such escape asymmetry and revealed its role in shaping speed-accuracy trade-offs in stochastic first-passage processes.

References:

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