Shaping optimal stochastic resetting via target distributions

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Implementation of stochastic resetting has been proven to be a useful strategy for optimizing search times. The most common setup comprises a one-dimensional Brownian searcher that diffuses and resets until hitting a fixed target. Since its inception, stochastic resetting has been a prolific line of research within the field of nonequilibrium statistical mechanics.

In this work, the Brownian searcher moves within a finite domain. It starts the search from the center of the box, and resets to the same position with a spatially dependent rate $r(x)$ not only in the bulk but also when hitting the boundaries, which we call resetting boundaries.

In contrast to standard resetting models, the target is not fixed at the same position, thereby mimicking uncertainty encountered in real scenarios. By analogy with quenched disordered systems, the target position is drawn from a given distribution in the finite closed interval for each realization. For a given distribution, our goal is to expedite the search via the heterogeneous strategy $r(x)$ to minimize the mean-first passage time (MFPT) to find the target. Interestingly, the optimal bulk resetting strategy may involve no resetting at all. For those cases, our introduction of resetting boundaries outperforms the usual bulk resetting scheme.

A general theoretical framework relying on the functional expansion of MFPT is put forward to analyze the stability of resetting strategies that only involves resetting boundaries, i.e., the stability of $r(x) = 0$. Our theory is checked by analyzing a particular monoparametric family of target distributions. Therein, a critical value of the parameter emerges, separating parameter regions in which bulk resetting is beneficial and detrimental. When the optimal heterogeneous strategy is not the trivial one, $r(x) \neq 0$, a numerical minimization of the functional MFPT is provided using gradient descent methods. These optimal nonzero solutions display a similar behavior for a variety of target distributions.