Optimal Search Strategies of Auto-chemotactic Walkers

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Stochastic search processes are ubiquitous in nature and are expected to become more efficient when equipped with a memory, where the searcher has been before. A natural realization of a search process with long-lasting memory is a migrating cell that is repelled from the diffusive chemotactic signal that it secrets on its way, denoted as auto-chemotactic searcher. To analyze the efficiency of this class of non-Markovian search processes we present a general formalism that allows to compute the mean first passage time (MFPT) for a given set of conditional transition probabilities for non-Markovian random walks on a lattice. We show that the optimal choice of the n-step transition probabilities decreases the MFPT systematically and substantially with an increasing number of steps. For a single auto-chemotactic searcher, an optimal coupling between the searcher and the chemical reduces the MFPT to 1/3 of the one for a Markovian random walk. This best point consists in a compromise between a blind diffusive search corresponding to the case with no interaction, and an ineffective ballistic search for the strong interaction case. However, when more searchers are present, this optimal searcher-cue coupling is modified to become infinitely strong as the density of walkers is high.

[1] H. Meyer and H. Rieger, Physical Review Letters 127, 070601 (2021).