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Profits from noise: the example of E. coli motion and chemotaxis

E. coli bacteria propel themselves through flagellar rotation. The control of the flagella is given through a rather simple signaling pathway, involving only a very small number of enzymes. Despite its simplicity this signaling pathway regulates a number of complex behaviors like chemotaxis, adaptation, and even Lévy walks. A Lévy walk is a special type of a random walk, characterized by a power-law run length distribution. It has been proven to represent the optimal search strategy to find randomly located and sparse targets. Interestingly, in *E. coli* bacteria the Lévy walk is a result of noisy fluctuations affecting the signaling pathway. We use a model of the signaling pathway given in the form of differential and algebraic equations, augmented by a stochastic term, to study the influence of noise on the concentration dynamics and the behavior of single cells and populations. Based on the model we derive the power-law run length distribution analytically in dependence on and statistical properties of the noise and properties of the signaling pathway. Our expression yields a power-law exponent of -2.2 which coincides with experimental data. We also use the model to simulate chemotactic behavior of large populations in different chemical landscapes. We show that also chemotactic behavior profits from noise, as it increases bacterial motility and behavioral variability.