A LEVY MOTION MODEL OF MICROBIAL DYNAMICS IN A PORE: NUMERICAL AND THEORETICAL RESULTS

Microbial motility is often characterized by 'run and tumble' behavior which consists of a bacteria making sequence of runs followed by tumbles (random changes in direction). A superset of Brownian motion, namely Levy motion, seems to describe such a motility pattern. Levy motion finds application in many other particle transport processes where long-range spatial correlation is preferred. The Eulerian (Fokker-Planck) equation describing these motions is similar to the classical advection-diffusion equation except that the order of highest derivative is given by a fractional number, $\alpha \in (0,2]$. It is shown analytically that for particle trajectories initially separated by a distance r and governed by symmetric α-stable Levy motions, the finite-size Lyapunov exponent (a measure of dispersive mixing) is proportional to the diffusion coefficient and inversely proportional to r^{α}. This power-law provides an easy method to determine parameters for Levy processes.

The Lagrangian equation of Levy motion, driven by a Levy measure with drift, is stochastic and employed to numerically explore the dynamics of microbes in a flow cell with sticky boundaries. The Eulerian equation is used to non-dimensionalize parameters. The amount of sorbed time on the boundaries is modeled as a random variable that can vary over a wide range of values. Salient features of first passage time are studied with respect to scaled parameters. A theoretical expression for computation of mean first passage time (breakthrough curve) is developed for Levy motion in a slit-pore with sticky boundaries. Comparison between theoretical results and numerical model suggests a good match.