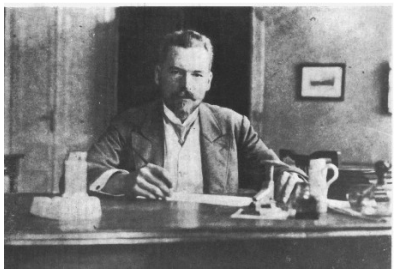

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Numerical Simulation of Lévy Flights Diffusion with Drift in Heterogeneous Membranes

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Understanding transport processes through membranes require the modeling of diffusion, particularly when it comes to enhancing process effectiveness. The goal of this research is to understand the relationship between membrane structures, external forces, and the characteristic features of diffusive transport. We investigate Cauchy flight diffusion with drift in heterogeneous membrane-like structures. The study focuses on the numerical simulation of particle movement across different membrane structures with differently spaced obstacles. Four studied structures are similar to those of sodium alginate membranes filled with iron oxide nanoparticles. The other three structures were designed specially to show the crucial factors that affect most diffusional transport under the influence of drift. The movement of particles driven by Cauchy flights is compared to a Gaussian random walk both with and without additional drift action. We show that effective diffusion in membranes with an external drift depends on the type of internal mechanism that causes the movement of particles as well as on the properties of the environment. In cases of weak drift, the effective diffusion is fully determined by the environment (i.e., the properties of the membranes), whereas the internal mechanism (i.e., Cauchy flight or Brownian motion) does not matter. Superdiffusion is typically observed when movement steps are provided by the long-tailed Cauchy distribution and the drift is sufficiently strong. On the other hand, strong drift can effectively stop Gaussian diffusion.

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