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Packets of Diffusing Particles Exhibit Universal Exponential Tails

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Brownian motion is a Gaussian process described by the central limit theorem. However, exponential decays of the positional probability density function $P(x,t)$ of packets of spreading random walkers, were observed in numerous situations that include glasses, live cells, and bacteria suspensions. We show that such exponential behavior, historically related to the work of Laplace, is generally valid in a large class of problems of transportin random media. By extending the large deviations approach for a continuous time random walk, we uncover a general universal behavior for the decay of the density [1]. It is found that fluctuations in the number of steps of the random walker, performed at finite time, lead to exponential decay (with logarithmic corrections) of $P(x,t)$. This universal behavior also holds for short times, a fact that makes experimental observations readily achievable. Time permitting, we will discuss the Hitchhiker model [2] which gives a microscopical description of the observed behavior, in terms of a model describing aggregation processes, that lead to a distribution of molecule sizes and to Laplace diffusion.

References

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