Exponential tails and asymmetry relations for the spread of biased random walks

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Exponential, and not Gaussian, decay of probability density functions was studied by Laplace in the context of his analysis of errors. Such Laplace propagators for the diffusive motion of single particles in disordered media were recently observed in numerous experimental systems. What will happen to this universality when an external driving force is applied? Using the ubiquitous continuous time random walk with bias, and the Crooks relation in conjunction with large deviations theory, we derive two properties of the positional probability density function P(x,t) that hold for a wide spectrum of random walk models: (I) Universal asymmetric exponential decay of P(X,t) for large |X|, and (II) Existence of a time transformation that for large |X| allows to express P(X,t) in terms of the propagator of the unbiased process (measured at a shorter time). These findings allow us to establish how the symmetric exponential-like tails, measured in many unbiased processes, will transform into asymmetric Laplace tails when an external force is applied.