Fluctuation relations for anomalous stochastic dynamics

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Fluctuation relations (FRs) emerged as a key concept for assessing fluctuations very far from equilibrium [1]. For stochastic processes generating normal diffusion they have been found to exhibit a characteristic large deviation form. We test them for stochastic processes generating anomalous diffusion [2]. We first consider Gaussian stochastic dynamics with memory by using a Langevin approach with two different types of additive noise: (i) internal noise where the fluctuation-dissipation relation of the second kind (FDR II) holds, and (ii) external noise without FDR II. For internal noise the existence of FDR II implies the existence of the fluctuation-dissipation relation of the first kind (FDR I), which in turn leads to conventional (normal) forms of transient work FRs. For systems driven by external noise we obtain violations of normal FRs [3]. We then study non-Gaussian stochastic dynamics generated by three different types of time-fractional Fokker-Planck equations. By considering both sub- and superdiffusive processes we recover again normal FRs if FDR I holds but observe violations if FDR I is broken [4]. Similar violations of FRs are observed in computer simulations of glassy dynamics and in experiments on biological cell migration.

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