Anomalous Transport and Fluctuation Relations: From Theory to Biology

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I briefly remind of Langevin dynamics modeling Brownian motion including the role of fluctuation-dissipation relations. The latter become especially important when Langevin dynamics is generalized by using (power law) memory kernels for the friction coefficient and/or the noise. Such correlations make the dynamics non-Markovian by typically generating anomalous transport in the form of anomalous diffusion, where the mean square displacement of an ensemble of particles grows nonlinearly for long times [1]. These Langevin models are tested for fluctuation relations generalizing the second law of thermodynamics to small systems in nonequilibrium [2]. I show that for generalized Langevin dynamics satisfying fluctuation-dissipation relations the conventional form of fluctuation relations is preserved while breaking fluctuation-dissipation relations leads to anomalous fluctuation relations violating the conventional form [3]. These generalized laws are observed in computer simulations of glassy dynamics and in experiments on biological cell migration.

[1] R. Klages, G.Radons, I.M.Sokolov (Eds.), *Anomalous transport: foundations and applications.* Wiley-VCH, Weinheim (2008)

[2] R.Klages, W.Just, C.Jarzynski (Eds.), *Nonequilibrium Statistical Physics of Small Systems.* Wiley-VCH, Weinheim (2013)

[3] A.V.Chechkin, F.Lenz, R.Klages, J.Stat.Mech. L11001 (2012); P.Dieterich, R.Klages, A.V.Chechkin, New J. Phys. 17, 075004 (2015)