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Nonlinear Fokker-Planck equations related to normal and anomalous diffusion

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In order to prove the H-theorem for a system in the presence of an external potential, a relation involving terms of the Fokker-Planck equation and the entropy of the system was recently proposed. In principle, one may have classes of Fokker-Planck equations related to a single entropic form. In the case of the standard Boltzmann-Gibbs entropy, apart from the simplest, linear Fokker-Planck equation, one may have a whole class of nonlinear Fokker-Planck equations, whose time-dependent probability distributions may be distinct from simple exponential distributions, presenting anomalous diffusion in the approach to equilibrium, but all of them related to the Boltzmann-Gibbs entropic form. All of these nonlinear Fokker-Planck equations, in the presence of a harmonic potential, yield Gaussian distributions as stationary states [1, 2]. The numerical integration of a subset of the class associated to the Boltzmann–Gibbs entropy is carried out and the dynamics of such systems is analyzed. For a particular subset of this class, presenting the same anomalous diffusion term as the one obtained for the porous media equation with suitable exponents, the nonlinearity induces temporarily stable long–tailed, or short–tailed distributions. The same qualitative scenario, presenting normal and anomalous diffusion, can be obtained if one uses a different entropic form, like the Tsallis entropy.

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[1] V. Schwämmle, E. M. F. Curado and F. D. Nobre, Eur. Phys. J. B 58 (2007) 159;

[2] V. Schwämmle, F. D. Nobre and E. M. F. Curado, Phys. Rev. E 76 (2007) 041123.