A Vlasov Equation Associated with the Nonlinear Fokker-Planck Equation: Time Dependent q-Gaussian Solutions

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There is a deep connection between nonlinear Fokker-Planck equations (NLFP) with power-law diffusion terms and the generalized thermostatistical formalism based upon the Sq family of entropic functionals. This NLFP-Sq connection has been the focus of a considerable research activity in recent years, and has found applications in various fields, ranging from the dynamics of vortices in type-II superconductors to the study of the dispersal of biological populations. In the present contribution we show that the aforementioned NLFP dynamics can be embedded within a Vlasov dynamical picture, describing a many-body system consisting of particles interacting via short-range forces, while moving under the effects of a drag force originating on a resisting medium, and a confining external potential. We obtain exact time dependent solutions of the q-Gaussian form for the associated Vlasov equations, and investigate their main properties. For vanishing drag, a conservative system admitting exact analytical (particular) time-dependent solutions is obtained. This constiutes new analytical evidence, supporting previusly existing numerical evidence, that q-Gaussian distributions arise naturally in some types of interacting many-body systems. In the limit of overdamped motion we recover the NLFP dynamics used, for instance, to model the motion of vortices in type-II superconductors.