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Fractional-diffusion models of anomalous diffusion

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Abstract

Reduced models of the turbulence shear-flow interaction have shown evidence of spatio-temporal propagating fronts during the L-H transition. In their simplest form, these models consists of reaction-diffusion equations in which the reaction kinetics models the dynamic coupling of the fields and standard diffusion operators (i.e. based on Ficks's law) model turbulent transport [1]. A general limitation of standard diffusion operators is their inability to describe non-Gaussian transport. That is, anomalous diffusion processes in which the mean-square displacement grows faster than linear (e.g. [2]). To explore the role of anomalous diffusion in the dynamics of fronts, we consider the Fractional-Fisher-Kolmogorov (FFK) model which is a reaction-diffusion equation with a fractional diffusion operator. In the absence of reaction kinetics, the FFK equation reduces to Feller's fractional diffusion equation whose solutions include Levy distributions. Numerical and analytical results are presented describing asymmetric ballistics-like transport, and accelerating fronts with algebraic decaying tails.

[1] D. del-Castillo-Negrete and B. A. Carreras, Phys. Plasmas, 9, 118 (2002), Physica D, (2002).
[2] D. del-Castillo-Negrete, Phys. Fluids, 10, 576 (1998).