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A Renormalization Group Theory of Spontaneous Stochasticity[1]

GREGORY EYINK, Johns Hopkins University, DMYTRO BANDAK, University of Illinois at Urbana-Champaign — Spontaneous stochasticity is persistent randomness in solutions of singular deterministic dynamics (ODE's, PDE's) for fixed initial data, as regularizations and stochastic perturbations are both taken to vanish. First identified in Lagrangian fluid particles undergoing turbulent Richardson dispersion[a], the effect was shown to be due to non-unique solutions of the singular initial-value problem and to be necessary for anomalous dissipation of both passive[a] and active[b] scalars. Even earlier, Lorenz[c] pointed out similar spontaneous stochasticity in turbulent solutions of Eulerian fluid equations, associated to intrinsic unpredictability, and the effect has been verified in numerical simulations of a self-similar turbulent mixing layer[d]. Here we describe a renormalization group method[e] that can determine whether spontaneous stochasticity occurs, calculate the universal statistics obtained at long times, and obtain finite Reynolds-number corrections. The method is illustrated on some simple models. [a]D. Bernard, K. Gawedzki, and A. Kupiainen, J. Stat. Phys. 90, 519–569 (1998) [b]T. D. Drivas and G. L. Eyink, J. Fluid Mech. 829, 153–189 (2017) [c]E. N. Lorenz, Tellus 21, 289–307 (1969) [d]S. Thalabard, J. Bec and A. Mailybaev, Commun. Phys. 3, 122 (2020) [e]https://arxiv.org/abs/2007.01333

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Gregory Eyink
Johns Hopkins University

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