Abstract Submitted
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Predator-prey effective model for the laminar-turbulent transition in a pipe[1] HONG-YAN SHIH, TSUNG-LIN HSIEH, NIGEL GOLDENFELD, Loomis Laboratory of Physics, University of Illinois at Urbana-Champaign — The goal of our work is to understand the phenomenology of the laminar-turbulent transition in terms of standard phase transition concepts, and to calculate the universality class from first principles. Direct numerical simulations (DNS) of transitional pipe flow show that a collective mode — a zonal flow — is activated by Reynolds stress and suppresses turbulence subsequently, leading to stochastic predator-prey-like oscillations. Here we describe in detail the effective stochastic theory for such spatial-extended predator-prey modes. We present Monte Carlo simulations of the effective theory, showing that it reproduces the phenomenology of pipe flow experiments, including the phase diagram of puff decay and splitting. In particular, the theory predicts a super-exponential lifetime statistics for both puff decay and puff-splitting, in agreement with experimental data on pipe flow, and can be mapped exactly to the field theory of directed percolation. Our calculations strongly suggest that transitional turbulence in pipes is in the universality class of directed percolation.

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