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Subcritical turbulence spreading and avalanche birth[1]

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Turbulence in confined plasma is known to self-propagate via nonlinear scattering. This phenomenon of "turbulence spreading" is of interest because it decouples the relationship between the local driving gradient and the local fluctuation intensity, in particular allowing linearly stable regions to be contaminated with fluctuations. This process has been traditionally modeled using a Fisher-KPP equation, a supercritical reaction-diffusion equation. However, such an approach suffers from a number of drawbacks. For one, it begs the question of why the turbulence hasn't already saturated due to linear instability. Moreover, the Fisher-KPP fails to predict any but the weakest of penetration into stable regions, which is dubiously consistent with clear observations of fluctuations in such regions. As a final reason to reconsider the older model, we note that a growing body of numerical and analytical work suggests the possibility of nonlinear instability and subcritical turbulence, neither of which are described by Fisher-KPP. In this work, we resolve the above issues by introducing a new *subcritical* model for turbulence spreading, featuring nonlinear instability drive. In addition to predicting stronger penetration of turbulence into stable regions via ballistically propagating fronts, this model predicts the possibility of bursty, intermittent propagation of turbulence similar to avalanches. We show that such an avalanche can be triggered when a threshold is exceeded, say due to noise, and estimate the threshold with a simple physical argument. These predictions provide avenues to test the model in experiment or simulation.

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