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Deviations from Kolmogorov-Kraichnan similarity theory in the energy cascade of two-dimensional alpha turbulence[1] BEL HELEN BURGESS, University of Toronto, THEODORE SHEPHERD, University of Reading — We study energy cascades in 2D α turbulence, for which "vorticity" θ is related to streamfunction ψ by $\theta(\mathbf{x}) = (-\boldsymbol{\Delta})^{\alpha/\mathbf{2}}\psi(\mathbf{x})$, where $(-\Delta)^{\alpha/2}$ is the fractional Laplacian. Using the eddy damped quasinormal Markovian (EDQNM) closure, we seek self-similar inertial range solutions. The energy flux is finite and the similarity solution self-consistent for $\alpha < 4$. In keeping with strain rate arguments, this suggests a spectrally local and self-similar energy cascade for $\alpha < 4$. However, the transfers vanish identically for $\alpha = 2.5$ and $\alpha = 10$. Comparison with statistical equilibrium spectra elucidates this: for $\alpha = 2.5$ and $\alpha = 10$, the similarity spectra coincide with enstrophy and energy equipartition respectively, and the similarity ranges are equilibrium solutions with Gaussian statistics. Moreover, the similarity range energy flux is toward small scales for $\alpha \in (2.5, 10)$, suggesting that any inverse cascade for $\alpha \geq 2.5$ cannot be self-similar. Numerical simulations confirm this: for $\alpha < 2.5$, one can obtain the similarity spectrum, while for $\alpha \geq 2.5$, the inverse cascade spectrum is significantly steeper than the similarity solution.

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