Abstract Submitted
for the DFD20 Meeting of
The American Physical Society

Self-similarity and the direct cascade in two-dimensional turbulence DMITRIY ZHIGUNOV, ROMAN GRIGORIEV, Georgia Institute of Technology — The multiscale nature of fluid turbulence arises as a result of various cascades transporting momentum between scales. This talk focuses on the direct (enstrophy) cascade responsible for the emergence of small-scale structure in two-dimensional turbulence. Existing understanding of this cascade is based primarily on the Fourier space analysis of Kraichnan, Leigh, and Batchelor (KLB) and implicitly assumes interaction between large and small scales. More recent studies Eyink and coworkers suggest that the physical mechanism of this cascade is related to stretching of vorticity field by the strain-dominated regions of the flow. We show that the KLB predictions can be derived and understood more naturally by analyzing the flow in the real space. Specifically, one can find in analytic form a family of self-similar solutions to the Euler equation which make this physical mechanism explicit, with vorticity field and the straining regions of velocity field describing, respectively, the small and large scales. These self-similar solutions immediately yield the k^{-3} energy scaling in the inertial range. The analysis can be extended to the Navier-Stokes equations, with viscosity yielding an exponential correction to the scaling law in the viscous sub-range.

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Date submitted: 03 Aug 2020 Electronic form version 1.4