

Abstract Submitted
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Macroscopic effects of the spectral structure in turbulent flows¹

T. TRAN, P. CHAKRABORTY, University of Illinois, N. GUTTENBERG, A. PRESCOTT, H. KELLAY, Centre de Physique Moléculaire Optique et Hertzienne (UMR 5798 CNRS), France, W. GOLDBURG, University of Pittsburgh, N. GOLDENFELD, G. GIOIA, University of Illinois — There is a missing link between macroscopic properties of turbulent flows, such as the frictional drag of a wall-bounded flow, and the turbulent spectrum. To seek the missing link we carry out unprecedented experimental measurements of the frictional drag in turbulent soap-film flows over smooth walls. These flows are effectively two-dimensional, and we are able to create soap-film flows with the two types of turbulent spectrum that are theoretically possible in two dimensions: the “enstrophy cascade,” for which the spectral exponent $\alpha = 3$, and the “inverse energy cascade,” for which the spectral exponent $\alpha = 5/3$. We find that the functional relation between the frictional drag f and the Reynolds number Re depends on the spectral exponent: where $\alpha = 3$, $f \sim Re^{-1/2}$; where $\alpha = 5/3$, $f \sim Re^{-1/4}$. Each of these scalings may be predicted from the attendant value of α by using a recently proposed spectral theory of the frictional drag. In this theory the frictional drag of turbulent flows on smooth walls is predicted to be $f \sim Re^{(1-\alpha)/(1+\alpha)}$.

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