Abstract Submitted
for the DFD10 Meeting of
The American Physical Society

Macroscopic effects of the spectral structure in turbulent flows[1]

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 $f \sim Re^{(1-\alpha)/(1+\alpha)}$.

[1]This work was financially supported by the US NSF through NSF/DMR grant 06-04477 and NSF/DMR grant 06-04435. T.T. acknowledges support from the Vietnam Education Foundation. P.C. acknowledges support from the Roscoe G. Jackson II Research Fellowship.

Tuan Tran

Date submitted: 10 Aug 2010 Electronic form version 1.4