APCOM Seminar

Center for Applied and Computational Mechanics
Graduate School of Science and Technology, Keio University
Date/time: November 9th, 2017, 17:00 to 18:00
Place: 3rd floor of Bldg 16A（厚生棟大会議室）

“The spectral link in turbulent frictional drag”

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Abstract: Two aspects of turbulent flows have been the subject of extensive, but separate, research efforts: the macroscopic properties and the turbulent spectrum. The macroscopic properties include the frictional drag experienced by a flow past a wall. The turbulent spectrum represents the statistics of fluctuations in the flow. The link, if any, between the macroscopic properties and the turbulent spectrum has remained missing. My talk concerns this missing “spectral link.” First, I will outline a spectral theory of the frictional drag that expresses the frictional drag as a functional of the turbulent spectrum. For three-dimensional flows in smooth and rough pipes, I will obtain an analytical version of the arch-famous Nikuradse’s diagram that is in minute qualitative agreement with the distinctive features in the diagram that have remained elusive to any theoretical elucidation. I will show that the exponents of the empirical scalings in the diagram are set by the attendant spectral exponent for “energy cascade” spectrum. Thereafter, I will consider quasi-two-dimensional turbulent flows—the realm of large-scale atmospheric and oceanic flows. I will describe unprecedented experimental measurements of frictional drag in turbulent soap-film flows over smooth walls, with two disparate types of turbulent spectra: the “enstrophy cascade," and the “inverse energy cascade.” I will show that the scaling of the frictional drag is set by the spectral exponent as per the predictions of the spectral theory of frictional drag. Last, I will describe preliminary results from flows where the spectral exponent is non-uniform in the wall-normal direction.

References

G. Gioia and P. Chakraborty, “Turbulent friction in rough pipes and the energy spectrum of the phenomenological theory,” *Phys. Rev. Lett.* **96**, 044502 (2006).

T. Tran, P. Chakraborty, N. Guttenberg, A. Prescott, H. Kellay, W. Goldburg, N. Goldenfeld, and G. Gioia., “Macroscopic effects of the spectral structure in turbulent flows,” *Nat. Phys.* **6**, 438-441 (2010).

H. Kellay, T. Tran, W. Goldburg, N. Goldenfeld, G. Gioia, and P. Chakrabort, “Testing a missing spectral link in turbulence,” *Phys. Rev. Lett.* **109**, 254502 (2012).

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