Physical Mathematics Seminar

Exploring the ultimate of turbulence and beyond

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ABSTRACT:

We mainly focus on DNS of two systems, Rayleigh-Bénard and Taylor-Couette flows, which share many similar features. In Rayleigh-Bénard turbulence, for the first time in two-dimensional numerical simulations we find the transition to the ultimate regime, namely at critical Rayleigh number $Ra^* = 10^{13}$. We reveal how the emission of thermal plumes enhances the global heat transport, leading to a steeper increase of the Nusselt number than the classical Malkus scaling. Beyond the transition, the temperature profiles are only locally logarithmic, namely within the regions where plumes are emitted, and where the local Nusselt number has an effective scaling $Nu \propto Ra^{0.38}$, corresponding to the effective scaling in the ultimate regime. In Taylor-Couette turbulence, we show how wall roughness greatly enhances the overall transport properties and the corresponding scaling exponents associated with wall-bounded turbulence. We reveal that if only one of the walls is rough, the bulk velocity is slaved to the rough side, due to the much stronger coupling to that wall by the detaching flow structures. If both walls are rough, the viscosity dependence is eliminated, giving rise to asymptotic ultimate turbulence—the upper limit of transport—the existence of which was predicted more than 50 years ago. In this limit, the scaling laws can be extrapolated to arbitrarily large Reynolds numbers. When the simulations are too big and computationally intractable to resolve all the scales, we introduce a data driven coarse grain method: we use neural networks to estimate high order statistics accounting for the small scale physics.

TUESDAY, OCTOBER 8, 2019
2:30 PM – 3:30 PM
Building 2, Room 131

Reception following in Building 2, Room 290
(Math Dept. Common Room)

http://math.mit.edu/seminars/pms/

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