Weekly CEAFM Seminar: Fall 2017

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Center for Environmental
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Date: **Friday, November 17, 2017**

Time: 11:00 AM

Location: Hodson Hall # 210

Speaker: **Prof. Pinaki Chakraborty** (Okinawa Institute of Technology)

Title: ***"The States of Flow in Transitional Pipes"***

Abstract

In 1883, Osborne Reynolds discovered a peculiar state for the flow of water in a pipe. This state corresponded to the transition from the quiescent, laminar state at low *Re* (Reynolds number, a dimensionless measure of the flow velocity) to the roiling, turbulent state at high *Re*. The laminar state is devoid of fluctuations; the turbulent state is inundated by a spectrum of fluctuations. Distinct from the laminar and turbulent states, the transitional state consists of localized "flashes" (Reynolds's term) of fluctuating flow alternating with plugs of laminar flow. Later work unveiled that the flashes come in two disparate states: "puffs," which can maintain their shape, proliferate or fade away; and "slugs," which ceaselessly expand. We take a closer look at the states of flow in transitional pipes.

First, we consider the "laws of resistance" (which relate the fluid friction with *Re*). Introduced by Reynolds in 1883, the laws of resistance furnish a quantitative diagnostic of the state of flow. While Reynolds succeeded in determining the laws of resistance for laminar and turbulent flows, the laws for transitional flows eluded him and remain unknown to this day. By properly distinguishing between flashes and laminar plugs in transitional flows, we show experimentally and numerically that the law of resistance for laminar plugs corresponds to the laminar law and the law of resistance for flashes is identical to that of turbulence. We conclude that flashes are turbulent *sensu* Reynolds.

Next, we consider the statistical structure of the fluctuations in the flashes about which little is known. Our experimental and numerical results suggest a surprising picture: the fluctuations in the flashes partake in the well-known Kolmogorov energy cascade, a signature of the high-*Re* turbulent state. In other words, flashes are turbulent *sensu* Kolmogorov.

To wit, despite appearances, transition is not a distinct state of flow—flashes are turbulent.

This work is in collaboration with Rory Cerbus, Chien-chia Liu, and Gustavo Gioia.