Abstract for an Invited Paper
for the DFD09 Meeting of
The American Physical Society

Patterns and dynamics in transitional shear flows

LAURETTE TUCKERMAN, PMMH-ESPCI-CNRS, France

One of the greatest mysteries in fluid dynamics is surely transition to turbulence. The classic shear flows – channel, plane Couette and pipe flow – while linearly stable, undergo sudden transition to 3D turbulence. In recent years, transition has been attacked with an arsenal of weapons from dynamical systems theory, such as low-dimensional chaos, unstable periodic orbits, heteroclinic connections, fractal basin boundaries. At the same time, 3D physical mechanisms such as streamwise vorticity and streaks have supplanted the 2D picture of linear instability long promoted by Squire's theorem. A striking recent discovery by experimentalists at CEA-Saclay is that large-aspect-ratio plane Couette flow near transition actually takes the form of a steady pattern of wide turbulent and laminar bands, with a fixed angle and wavelength. We have been able to reproduce these remarkable flows in numerical simulations of the Navier-Stokes equations. Simulations display a rich variety of variants of these patterns, including spatio-temporal intermittency, branching and travelling states, and localized states analogous to spots. Because similar patterns have since also been observed in Taylor-Couette, channel and pipe flow, it appears that they are inevitable intermediate states on the route from turbulent to laminar flow in large aspect-ratio shear flows. In addition to their intrinsic interest, these patterns provide clues to the transition to turbulence.