Simulations of turbulent transition in long pipes

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Motivated by recent progress in understanding turbulent transition in pipe flow[1] and, in particular, experimental studies of long pipes of many hundreds of diameters[2,3], we have undertaken the direct numerical simulation of turbulence in long pipes at transitional Reynolds numbers. We have employed high-performance parallel computations using a spectral-element code to solve the Navier-Stokes equations in a Cartesian geometry[4]. This code uses a spectral-element discretization along circular cross-sections of the pipe, with a Fourier expansion in the remamining streamwise direction (necessitating the use of a periodic boundary condition). The flow is driven by use of a body-force in order to simulate a constant pressure gradient, although simulations for a fixed flow rate are also possible.

With these techniques we estimate that we will be able, for the first time with direct numerical simulation, to obtain results for pipe lengths of several hundred diameters. We report on preliminary findings from these studies up to Re $\simeq$ 5000. Figure 1 shows some initial results from simulations of fully-developed turbulence at this Reynolds number.

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[1]B. Hof et al., *Science* **305** 1594 (2004).
[2]J. Peixinho, T. Mullin, *J. Fluid Mech.* **582** 169 (2007).
[3]B. Hof, B. Eckhardt et al., *Nature* **443** 59 (2006).
[4]D.M. McIver, H.M. Blackburn et al., *ANZIAM J* **42**(E) C954 (2000).

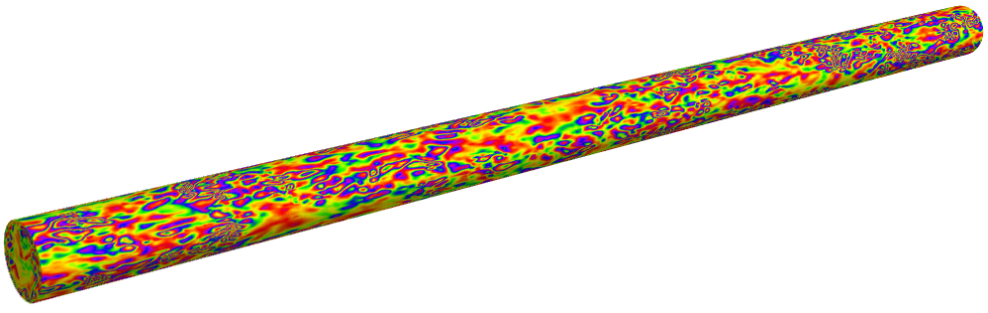

Figure 1: Streamwise vorticity in numerical simulations of turbulent pipe flow at Re $\simeq$ 5000.