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Travelling waves in pipe flow and their relevance for transition to turbulence

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The problem of understanding the nature of pressure-driven fluid flow through a circular straight pipe remains one of the oldest problems in fluid mechanics. The steady, unidirectional parabolic (laminar) flow solution named after Hagen (1839) and Poiseuille (1840) is linearly stable yet temporally and spatially disordered 3-dimensional (turbulent) solutions can easily be triggered at sufficiently large flow rates (Reynolds 1883). In contrast with Rayleigh-Benard convection where transition to turbulence proceeds along an orderly sequence of bifurcations at well-defined values of the thermal driving, the transition in a pipe is abrupt, dependent on the level of ambient disturbances in the system and, at least close to the threshold flow rate, transient. The recent discovery of travelling wave solutions (which represent saddle points in phase space) in this system has at last provided a theoretical stepping stone towards rationalizing the transition process. We will discuss the structure of these waves as well as evidence of their relevance during the transition process.