LadHyX Seminar – September 21, 10:45

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Linear and nonlinear dynamics of pulsatile flows

Pulsatile flows are found in a wide range of industrial applications and play a key role in the human body. Progress in the characterization of hemodynamics and its role in the development of cardiovascular diseases will require, among others, a better understanding of these flows and of the details of the associated wall shear stress. While purely oscillating flows have already been widely investigated, pulsatile situations are not yet sufficiently understood. Indeed, the presence of both a mean flow and a periodic component is an essential element in fluid biomechanical configurations. Thus, this work was undertaken to systematically study the linear and nonlinear dynamics of pulsatile flows in the fundamental case of a parallel geometry. The basic flow is then entirely determined by the Reynolds number (based on the mean flow rate), the Womersley number (a measure of the frequency) and the shape of the pulsation. The linear stability properties are obtained by Floquet analysis and direct numerical simulation of the linearised Navier-Stokes equations, while the fully developed dynamics are studied by simulation of the complete equations. Essentially two nonlinear regimes have been identified: (1) A "cruising" regime where the nonlinearities are maintained throughout the pulsation cycle. This results in time-modulated finite amplitude waves which can be interpreted as modulated Tollmien-Schlichting waves. (2) A "ballistic" regime where linear and nonlinear phases alternate periodically: during each cycle, the flow is propelled into a nonlinear regime before falling back to negligible amplitudes.