# Instabilities and transition to turbulence in periodic flows

Understanding the mechanisms underlying transition to turbulence for increasingly complex flow configurations is a very active area of research and a critical enabler for high-stake innovation in transportation industry (e.g. drag reduction or lift increase). One of the key issues however is that there is no unique route to turbulence. The particular transition mechanisms at play highly depend on the nature of the external forcing (viz. surface roughness, process noise, frequency content, spatial location). For over fifty years, these physical mechanisms have essentially been elucidated for flow configurations initially characterized by a (conditionnaly stable or linearly unstable) steady equilibrium. Transition of time-periodic flows (either forced or having already experienced a number of Hopf bifurcations) in realistic three-dimensional geometries has attracted much less attention, essentially due to the added complexity when studying such flows from a numerical perspective.

Predicting the onset of unsteadiness in complex three-dimensional geometries relies on the use of high-performances computational fluid dynamics simulation codes and iterative eigenvalues solvers. For the flow configuration considered, linear stability analyses predict the onset of Taylor-Görtler vortices at a critical Reynolds number Re = 3450, in excellent agreement with one observed experimentally at LIMSI (Re = 3370).

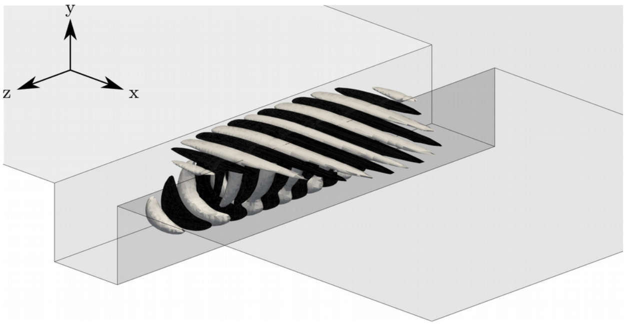

**Figure:** Primary instability mode for a realistic shear-driven cavity flow obtained by means of eigenvalue analysis of the corresponding large-scale eigenvalue problem.

Over the past decade, members of the laboratory DynFluid have succesfully developped innovative numerical methods to study very large-scale nonlinear dynamical systems and get a better understanding of their stability properties, mostly for stationnary equilibria. Within this context, the PhD candidate will have to extend the existing numerical tools as to compute unstable time-periodic equilibria and study their linear and nonlinear stablity properties. One of the configurations to be investigated is that of the shear-driven cavity flow (see figure), an open-shear flow also experiencing centrifugal instabilities. Collaborations with experimentalists at LIMSI (Orsay, France) are strongly encouraged to compare predictions of the stability analyses against experiemental measurements.

**Location :**

The PhD candidate will be located at DynFluid in Ecole Nationale Supérieure d'Arts et Métiers, Paris.

**Grant :**

The PhD candidate will be awarded a three-year research grant from the French Ministry of Higher Education and Research for the completion of his doctoral studies.

**Background :**

Candidates need to have a Master in Science (or equivalent) in fluid dynamics or applied mathematics. Given the nature of the work to be done, some programming skills (Fortran and Python) and basic knownledge in dynamical systems theory are highly recommended.

**Contacts** :

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