Introduction to hydrodynamic instability

The course introduces the fundamental concepts and techniques of instability theory in the context of fluid mechanics. Several common types of flow instability and the underlying physical mechanisms are discussed. Linear stability analysis is performed by use of the method of normal modes. Local instability properties (temporal, spatial and spatio-temporal growth in parallel base flows) are discussed for the example of a free shear layer; the concepts of transient growth and optimal perturbation are introduced and tested for plane Poiseuille flow. The stability of nonparallel steady flow, like the cylinder wake, is characterised in terms of global eigenmode analysis.

During exercise sessions, which are integrated within the four-hour teaching blocks, students will use basic python (numpy) and the FEniCS library on their own computers to gain numerical hands-on experience with the theoretical concepts developed in the lectures. The evaluation is based on a final group project, extending over several weeks.

Prerequisite: Master 1 level with good knowledge of fluid mechanics and basic linear algebra (matrix operations, eigenvalue problems). Advanced programming abilities are not required, but it will necessary to acquire some command of numpy during the course.

Bibliography:

F. Charru: "Hydrodynamic Instabilities", Cambridge University Press, 2011. (Suggested reading, not required.)

Timing: The course is offered in the first part (September-November) of the M2 year.

Credits: 3 ECTS

Hours: 28 hours + project presentation