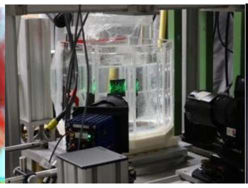
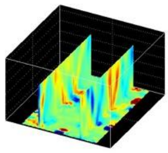
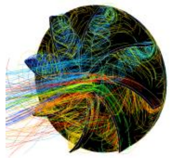
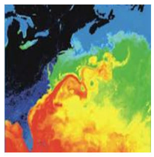
INTERNSHIP 2018/2019

TRANSITIONS IN NON-EQUILIBRIUM TURBULENT SYSTEMS

Sudden transitions are observed in many natural systems: atmosphere, ocean, climate, Earth's magnetic field... These systems are complex: they have many interacting spatial and temporal scales and are subject to very large fluctuations at all these scales. Medium structures such as trade winds, Gulf Stream, ice ages and interglacials can be defined. These structures can appear, disappear or transform through transitions that involve spontaneous breaks in the symmetries of the system and can be compared to phase transitions or bifurcations. However, these phenomena are still poorly understood at present, although they are of crucial importance for the dynamics of the climate system, for example. In this thesis, we propose to experimentally study a turbulent / fluid model system, where transitions can be observed on some observable mean or global observables.

The phase transitions in model systems close to thermodynamic equilibrium are well known and the physics of instability and chaos has enabled considerable progress to be made over the past 30 years for systems with small numbers of degrees of freedom. Similarly, the influence of noise on a transition has been successfully studied in many systems. This is not the case for complex systems located far from equilibrium in which the fluctuations are of the same order as the average values. Indeed, although laboratory experiments have recently revealed transitions in turbulent systems, a conceptual framework has yet to be developed.

The aim of this internship is to address this issue using model experiments. Part of the work will be based on a sheared flow in a closed cylinder forced by two turbines and very highly turbulent. In this type of flow, we can observe average structures of different symmetries that can coexist for some values of the control parameters. Complex and slow temporal dynamics can then lead to transitions between these modes. Beyond the experimental studies, one of the objectives of the internship will also be to compare the dynamics and transitions observed with recent results obtained in statistical mechanics and in non-linear or stochastic models.

The core of this internship is experimental, but theoretical developments on out-of-equilibrium physics via multi-fractal formalism and wavelets can be carried out. This thesis will be co-supervised by F. Daviaud (CEA) and B. Dubrulle (CNRS). The internship subject requires a solid background as a physicist, particularly in statistical physics, as well as a strong taste for experimentation. It may eventually lead to a thesis on a related topic.

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