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Experimental study of bistable dynamics for a thick profile in stall limit.

Context

Turbulent flows are ubiquitous in natural phenomena and engineering applications and therefore a mathematically tractable description of them is desirable for their prediction and control. During the transitional regime, continuous spatial and temporal symmetries are spontaneously broken. Although bifurcations break the symmetries during the transition to turbulence, fully developed turbulence is known to restore the possible symmetries in a statistical sense at very high Reynolds numbers [1, 2]. For intermediate Reynolds numbers only some symmetries are broken, this means that the dynamics of such flows has coherent structures and similar structures of the laminar instabilities observed in the transitional regimes, in a statistical sense. These persisting instabilities at the turbulent regime, are associated with spatial and temporal symmetry breaking, giving rise to spatial reflectional symmetry and quasi-periodic vortex shedding. The influence of turbulence recovers the lost temporal and spatial symmetries in the long-time average.

The dynamics of the turbulent three-dimensional wake flow generated by a thick symmetric airfoil at high angle-of-attack are experimentally investigated (Fig. 1). When the angle-of-attack is closed to stalling angle, the analyses of the coherent dynamics of the wake reveal the presence of two very distinctive time scales. At long time the recirculation region shifts between two different states leading to a statistically different wake (and then different lift and drag) ; the sequence of these states is random. This dynamic randomly jump between two distinct states is linked to a bi-stable behavior (see Fig. 2 for a three-dimensional blunt body case). Bistability is defined as the capability of a flow to adopt two stable states. Bistable flow patterns may exist, i.e. conditions having two possible equilibrium states with different flow configurations (and consequently different aerodynamic loads). If one includes weak stochastic fluctuations in these bistable regimes the system may undergo spontaneous non-equilibrium phase transitions from one attractor to another.

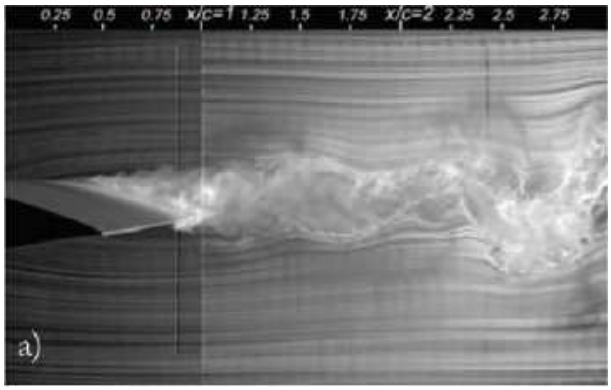

Figure 1 – Flow visualizations for NACA0025 aerofoil at $Re = 0.55 \times 10^5$ (see, [5]).

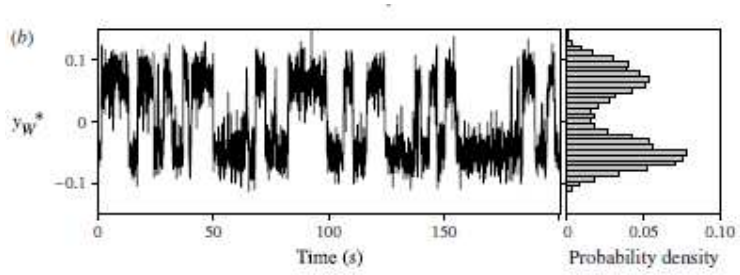

FIGURE 2 – Time evolution of the barycentre of momentum deficit in the y-direction and associated probability distribution for a turbulent wake past a three-dimensional blunt body (see, [3, 4]).

Objective

The main objective of this postdoctoral work is to study experimentally this bistable dynamics for a thick profile as NACA0035.
The ENSAM/DynFluid wind tunnel will be used to study and to characterize this bistable dynamics. This work will be carried out over one year.
The candidate will develop the experiment, being able to provide global measurements (drag and lift) but also have skills in PIV visualization techniques and pressure measurements. He will also be able to perform unsteady measurements and to perform advanced post-processing signal (statistical processing, POD, DMD, DFT, correlation,...).

Localization and funding

The work is realised in DynFluid laboratory at Arts et Métiers ParisTech.
Funding : Arts.
Period of postdoctoral position : one year (begin : last trimester of 2016).
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Références

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