The role of fluctuations on a bistable pendulum in a flow

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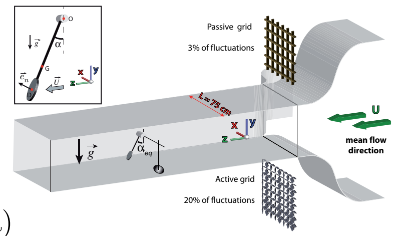
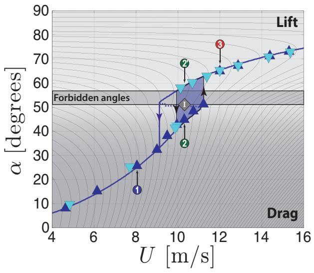


(a)



(b)

The simple pendulum remains one of the most fundamental systems studied in physics. It is commonly used as a model to illustrate a broad variety of mechanisms in a wide range of areas. However, in spite of this popularity, subtle behaviors still remain to be discovered and to be explored when the pendulum is strongly coupled to fluid mechanics. In a recent work (Obligado *et al.*, Journal of Fluid Mechanics **728** (2013)) we have for instance shown that the equilibrium of a pendular disk facing a flow (figure (a)) exhibits bi-stability and hysteresis (figure (b)). We have given a simple quantitative interpretation of this behavior in terms of a two potential wells description, only requiring to know the angular dependency of the normal drag coefficient of a fixed inclined plate. We have also shown that the hysteretical behavior is strongly influenced by the turbulence level of the incident flow (our experiment runs in a low-turbulence wind tunnel where a passive or an active grid, , shown in figure (a), can be used as turbulence generators).

While previous work has mostly focused on the average equilibrium position of the pendulum, a deeper analysis of the role of oscillations and fluctuations (both of the pendulum and of the flow) remains to be achieved. Fluctuations are particularly important in the context of bi-stable systems, as they can promote transitions between the two stable potential wells, resulting in a non-trivial dynamics of system. We will investigate experimentally the possibility for spontaneous transitions between the bi-stable branches to occur as well as the influence of external noise on escape times statistics (a question known as Kramers problem in the context of stochastic multi-stable systems). Different sources of fluctuations will be considered : (i) natural oscillations of the pendulum (eventually amplified by an external resonant mechanical forcing), (ii) turbulent fluctuations of the carrier flow and (iii) aerodynamically forced oscillations (for instance in the wake of a cylinder) either resonant or non-resonant with respect to the natural frequency of the pendulum. The ability of the bi-stable pendulum to undergo stochastic resonance will also be investigated.