Data-driven discovery of stochastic model of bistable wake past two square cylinders

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When two bars of rectangular (or circular) cross-sections H with finite spacing G are placed perpendicular to an incoming flow (Fig. 1, left), the instantaneous symmetry of the jet between the cylinders is broken below a critical spacing (Fig. 1, center) and the flow becomes bistable [1] (Fig. 1, right). This bistability leaves clear marks in the drag and lift forces on each cylinder, similar to other bistable bluff body wakes. We have studied the phenomenon using Particle Image Velocimetry measurements performed in the LMFL wind tunnel for several gap ratios G/H [3] (Fig. 1, left). A clear mechanism driving the switch, and links between the switchs and faster processes of the flow have not been proposed yet. We explored possible origins of the switch by slightly twisting the one of the rectangular bar and increasing the sampling rate of our PIV measurement by a factor 20.

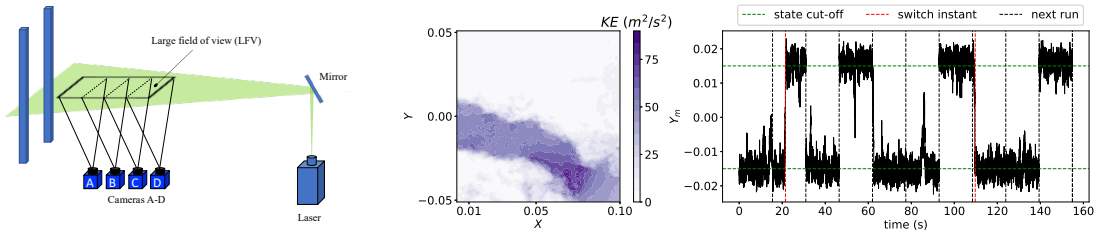

FIGURE 1: Left : sketch of the experimental setup, center : kinetic energy in the plane perpendicular to the bar showing one metastable configuration, right : time series for average jet position for 10 runs of the experiment.

In our experiments, we observe that waiting time distribution for the mean jet position satisfies a Poisson law (Fig. 1, right). In order to obtain scalar quantities that control the properties of the metastable system, (mean waiting times before switches, angle of tilt of the jet), and have models that can be used for efficient resampling of data, we construct analytic stochastic differential equations (SDE) representing the features of the flow, like the jet position. After quantitatively checking that our data can be represented by a Markov process at its sampling rate, we perform an automated search for the analytically formulated SDE that best represents the observed data, following a recently proposed methodology [2]. This procedure selects analytical terms and computes their coefficients by choosing a balance between the best fit of the dynamics and PDF of our features on the on one hand, and simplicity of the model on the other hand.

Références

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