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From handcrafted Galerkin models to automated cluster models

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Reduced-order models (ROM) are of paramount importance for physical understanding, data compression, estimation, control and optimization. Over a century ago, simple dynamical models of coherent structures have been facilitated by stability theory (Orr-Sommerfeld equation 1907) and by vortex models (von K arm an 1911). Data-driven reduced-order modeling of coherent structures has been pioneered by Aubry et al. (1988) with a celebrated POD model of the turbulent boundary layer. Since then, machine learning [1] has significantly simplified and enriched the spectrum of possibilities for data-driven ROM.
In this talk, we exemplify different ROM approaches for the fluidic pinball [2], the wake flow behind a cluster of three parallel cylinders on an equilateral triangle pointing upstream. The flow may be actuated by rotating cylinders. First, the transition scenario of the unforced fluidic pinball is modeled with a five-mode mean-field Galerkin model. This model comprises successive Hopf and pitchfork bifucations, which are typical for a number of wake flows. Second, a cluster-based network model (CNM) [3, 4] is presented describing the fluidic pinball wake with actuation as free input, employing thousand differently actuated pinball simulations. CNM yields a robust dynamics from a fully automatable procedure. Finally, perspectives of ROM for common tasks of data management are given.
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