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Least-order model for the transient dynamics of the fluidic pinball NAN DENG, IMSIA, ENSTA-Paris, IP-Paris, France and LIMSI, UPSaclay, France, LUC R. PASTUR, Institute of Mechanical Sciences and Industrial Applications, ENSTA-Paris, Institut Polytechnique de Paris, France, BERND R. NOACK, Center of Turbulence Control, Harbin Institute of Technology, China and ISTA, Technische Universitt Berlin, Germany, MAREK MORZYNSKI, Chair of Virtual Engineering, Poznan University of Technology, Poland — We propose a least-order mean-field model for a flow system undergoing two successive supercritical bifurcations. The fluidic pinball, an incompressible two-dimensional flow crossing three equidistantly spaced cylinders, is numerically investigated using Direct Numerical Simulation. Two generic bifurcations in fluid mechanics are observed: the primary Hopf bifurcation leads to a statistically symmetric vortex shedding and the following pitchfork bifurcation breaks the symmetry at higher Reynolds number. Interestingly, this symmetry-breaking instability works on the steady solution simultaneously, illustrated by the global stability analysis and Floquet analysis. The elementary degrees of freedom are identified under mean-field considerations exploiting the symmetry/asymmetry of the base flow and the fluctuation. An easily interpretable five-dimensional Galerkin model compatible with the quadratic non-linearities of the Navier-Stokes equations is derived, which can reproduce the main features of bifurcating dynamics and the transient behavior to the asymptotic regime. This generalized mean-field Galerkin methodology is considered to be applicable to other transition scenarios and nonlinear model-based control.

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