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Reduced-Order Models of a Natural Convection Loop for Known Heat Flux Conditions via Karhunen-Loève Expansions[1] TOBIAS HUMMEL, ARTURO PACHECO-VEGA, California State University, Los Angeles — We build reduced-order dynamical models of a thermal convection loop using the Karhunen-Loève decomposition (KL) methodology, in conjunction with the Galerkin projection technique. The convective loop has the form of a torus and is filled with a water. The loop receives heat in some parts and releases it in others through a known-heat-flow sinusoidal function, thus creating a natural circulation. Under suitable assumptions, the momentum and energy equations are reduced to a set of one-dimensional integro-differential equations, in which the tilt angle of the loop and the heat rate per unit length are the bifurcation parameters. The set of equations is first solved via finite differences to generate numerical solutions from which the KL model can be built. Then, the method of snapshots and the Galerkin projection are applied to find the KL basis functions, and the corresponding constants, that generate the most compact dynamical system. It is found that the number of KL modes required to build a model is a function of the linear stability of the steady states. As the system goes from stable to unstable regions, and finally to chaos, the number of required modes increases. However, for an accuracy level of, e.g., 10^{-4}, these reduced-order models are at five orders of magnitude faster than the finite difference solver.

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