Structure-preserving dynamical model order reduction of parametric Hamiltonian systems

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In real-time and many-query simulations of parametric differential equations, computational methods need to face high computational costs to provide sufficiently accurate and stable numerical solutions. To address this issue, model order reduction aims at constructing low-complexity high-fidelity surrogate models that allow rapid and accurate solutions under parameter variation. In this talk, we consider the model order reduction of parametric Hamiltonian dynamical systems describing non-dissipative phenomena. The development of reduced order models of such systems is challenged by several factors: (i) failing to preserve the geometric structure encoding the physical properties of the dynamics might lead to instabilities and unphysical behaviors of the resulting approximate solutions; (ii) the local low-dimensional properties of non-dissipative phenomena demands large reduced spaces to achieve sufficiently accurate approximations; and (iii) nonlinear operators require hyper-reduction techniques that preserve the gradient structure of the flow velocity. We will discuss how to address these aspects via a nonlinear model order reduction approach based on evolving low-dimensional surrogate models on a phase space that adapts in time while being endowed with the geometric structure of the full model.

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