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Structure-preserving model reduction: From the formulation on manifolds to data-driven realizations

Tuesday, March 3, 2026 8:30 AM (45 minutes)

Capturing and preserving physical properties, e.g., system energy, stability, and passivity, using data-driven methods is currently a highly researched topic in surrogate modeling. To ensure that the desired physical properties are retained, structure-preserving projection techniques are used in model order reduction (MOR). In this talk, we present structure-preserving MOR with nonlinear projections, which are needed for problems with slowly decaying Kolmogorov n-widths. To precisely define and highlight the quantities we would like to retain, we start with a formulation of initial-value problems on manifolds, which we consider the full-order model (FOM). Already at this level, we define what we mean by adding structure to the FOM and how this can be detailed geometrically. This formalism allows to introduce a novel projection technique, the generalized manifold Galerkin (GMG). By adapting the underlying non-degenerate tensor field, this GMG projection can be used for a structure-preserving reduction of various initial value problems that give rise to interesting physical properties, including, but not limited to, Lagrangian and (port-)Hamiltonian systems.
Once we have derived the geometric formulation, we focus on data-driven ansatzes to realize the presented reduction methods. In this part of the talk, we will connect several existing data-driven techniques with GMG projections.

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