Structure-preserving dynamical reduced order models for Hamiltonian systems

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The development of reduced basis methods for Hamiltonian systems describing nondissipative phenomena, like wave-type and transport dominated problems, is challenged by two main factors: the geometric structure encoding the physical and stability properties of the dynamics and its local low-rank nature. In this talk, we will present a way to address these aspects by a nonlinear structure-preserving model reduction where the reduced phase space evolves in time. In the spirit of dynamical low-rank approximation, the reduced dynamics is obtained by a symplectic projection of the Hamiltonian vector field onto the tangent space of the approximation manifold at each reduced state. Splitting techniques are employed for the temporal discretization of the reduced dynamics. The reduced basis satisfies an evolution equation on the manifold of symplectic and orthogonal rectangular matrices having one dimension equal to the size of the full model. We will present intrinsic temporal integrators based on Lie group techniques and explicit Runge–Kutta (RK) schemes to approximate the problem recast on the tangent space of the matrix manifold. Using partitioned RK methods the approximate reduced dynamics is structure-preserving and its computational complexity depends only linearly on the dimension of the full model, provided the evaluation of the reduced flow velocity has a comparable cost.