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Reduction of Non-Linearizable Dynamics to Spectral Submanifolds

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The currently developing array of machine learning techniques in engineering and applied sciences includes methods for fitting reduced-ordered models to dynamic observables. Related techniques are various versions of the dynamic mode decomposition (DMD) supported by Koopman analysis. These methods are very efficient in reproducing linear or linearizable dynamics, but are unable to model intrinsically nonlinear (i.e., non-linearizable) phenomena. Such phenomena include dynamical behavior with multiple, disjoint coexisting stationary states, such multiple equilibria, periodic orbits, quasi-periodic orbits and chaotic attractors.

An emerging approach to model non-linearizable dynamics from data utilizes the theory of spectral submanifolds (SSMs), which are nonlinear continuations of the slowest non-resonant spectral subspace of a linearized system [1,2]. These attracting slow manifolds also capture nonlinear dynamics outside the domain of attraction of a stable fixed point and hence their reduced dynamics can provide a reduced model with coexisting stationary states.

In this talk, we survey the basics of SSM theory and available software packages that compute SSMs and their reduced dynamics for very high-dimensional systems. We also mention recent technical developments, outstanding extensions of SSM theory and survey its applications to modelling and prediction in structural vibrations and fluid dynamics [3,4].

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