An Introduction to Multiscale Data-Driven Modal Analysis and Model Order Reduction

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Many systems in engineering and applied sciences are governed by multi-scale, nonlinear dynamical processes. While the evolution of numerical and experimental tools allows for datasets with ever-growing spatial and temporal resolutions, data processing algorithms must be able to extract the relevant dynamics from large and high-dimensional datasets. This distillation process is the purpose of data-driven model order reduction (MOR), which lays the foundations of modern data compression, data filtering, pattern recognition, and machine learning, and which is becoming an essential tool for any applied scientist.

This seminar provides an introduction to data-driven decompositions, from their general mathematical framework to their typical application on numerical and experimental data. Two classical decompositions are analyzed in details: the Proper Orthogonal Decomposition (POD) and the Dynamic Mode Decomposition (DMD). Several examples are presented to highlight their strength and limitation and used to motivate the need for more advanced hybrid decompositions. Finally, the seminar gives an overview of the Multiscale Proper Orthogonal Decomposition (mPOD), a recently proposed formulation that allows overcoming the major limitations of the existing formulations.

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