

# AA216/CME345: PROJECTION-BASED MODEL ORDER REDUCTION

## 1. Introduction

- 1.1 Physics-based modeling and simulation: CPU cost
- 1.2 What is model reduction?
- 1.3 How is it done today?
- 1.4 When does it pay off?
- 1.5 Examples

## 2. Parameterized Partial Differential Equations

- 2.1 Initial boundary value problems
- 2.2 Parameters of interest
- 2.3 Semi-discretization processes and dynamical systems
- 2.4 Case for model reduction
- 2.5 Subspace approximation

## 3. Projection-Based Model Order Reduction

- 3.1 Solution approximation
- 3.2 Orthogonal and oblique projections
- 3.3 Galerkin and Petrov-Galerkin projections
- 3.4 Equivalent high-dimensional model
- 3.5 Error analysis

## 4. Proper Orthogonal Decomposition (POD)

- 4.1 Time-continuous formulation
- 4.2 Method of snapshots for a single parametric configuration
- 4.3 POD method in the frequency domain
- 4.4 Connection with SVD
- 4.5 Error analysis
- 4.6 Extension to multiple parametric configurations
- 4.7 Applications

## 5. Linear Dynamical Systems

- 5.1 External description
- 5.2 Internal description
- 5.3 Exact solution
- 5.4 Congruence transformation
- 5.5 Stability

## 6. Balanced Truncation

- 6.1 Reachability and observability
- 6.2 Balancing
- 6.3 Balanced truncation method
- 6.4 Error analysis
- 6.5 Stability analysis

- 6.6 Computational complexity
- 6.7 Comparison with POD
- 6.8 Applications
- 6.9 Balanced POD method

## **7. Moment Matching**

- 7.1 Moments of a function
- 7.2 Moment matching method
- 7.3 Krylov-based moment matching methods
- 7.4 Comparison with POD and Balanced POD in the frequency domain

## **8. Local Parametric Approaches**

- 8.1 Database concept
- 8.2 Interpolation of reduced-order bases on quotient manifolds
- 8.3 Interpolation of reduced-order models on embedded manifolds

## **9. Nonlinear Projection-Based Model Order Reduction**

- 9.1 Nested approximations
- 9.2 Quadratic approximation
- 9.3 Arbitrarily nonlinear approximation using deep learning
- 9.4 Piecewise approximations
- 9.5 Hyperreduction

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