RÉPUBLIQUE FRANÇAISE
*Liberté*
*Égalité*
*Fraternité*

# Non Linear Compressive Reduced Basis approximation for PDE's

PhD Candidate: Hassan Ballout[1]
Supervised by: Prof. Prud'homme[1], Prof. Maday[2], Dr. Aghili[1]

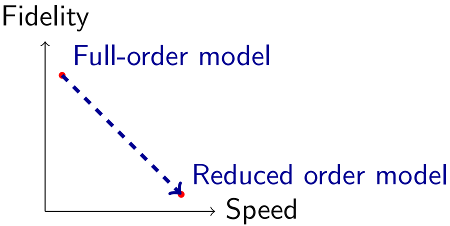
January, 2025

[1]Université de Strasbourg
[2]Sorbonne Université

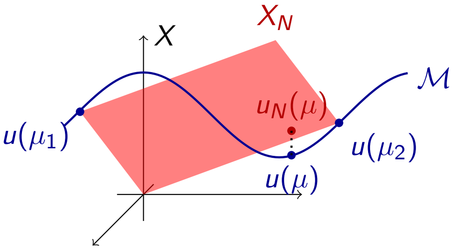
FRANCE 2030
PROGRAMME DE RECHERCHE
*NUMÉRIQUE POUR L'EXASCALE*

# Context: Model Order Reduction

- **Objective**
  - Reduce computation time.
  - Preserve a reasonable level of accuracy.




- **Classical Techniques:** Linear RBM.
  - Build a reduced-dimensional subspace in the offline phase.
  - Reduced (#DOF) $\Longrightarrow$ Faster online phase.



# Efficiency of Model Order Reduction Methods

- **Classical Linear RBM:**
  - Works perfectly for certain problem classes (e.g., elliptic problems).
  - Ineffective for others, like hyperbolic problems.
- **Kolmogorov Width:**
  - The slow decrease of the Kolmogorov $n$-width highlights the inefficiency of linear methods.
- **Solution: Nonlinear Compressive RBM:**
  - Based on the notion of sensing numbers.
  - Utilizes a nonlinear decoder approximated using ML/DL techniques.

# Objectives

- Mitigate the slow convergence of Kolmogorov width, focusing on the Navier-Stokes equations.
- Leverage Exa-MA project resources to manage large offline computational costs.
- Ensure that the developed algorithms and methods are optimized for exascale architectures.

**First Publication:** H. Ballout, Y. Maday, C. Prud'homme, "Nonlinear compressive reduced basis approximation for multi-parameter elliptic problems", in *Multiscale, Nonlinear and Adaptive Approximation II*, edited by R. DeVore and A. Kunoth, Springer, 2024, pp. 55–73.

Thank You for Your Attention!