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FRANCE 2030 PROGRAMME DE RECHERCHE NUMÉRIQUE POUR L'EXASCALE

# Neural Operator and Model Reduction

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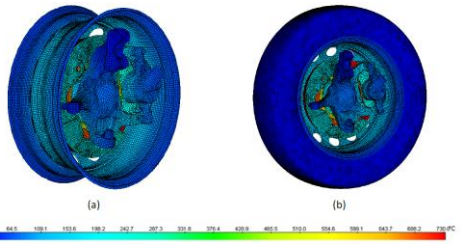
# Motivation

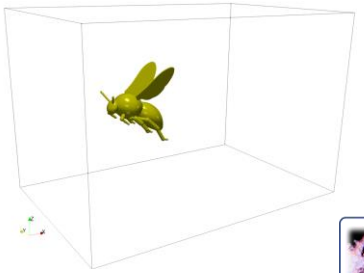
Many problems in science and engineering involve solving complex PDE:

$$\mathcal{L}u(x,\mu) = f\big(u(x,\mu)\big), BC + IC$$

- micro-mechanics
- turbulent flows
- climate model
- and many more

Often such systems require fine discretization and thousands of evaluations.



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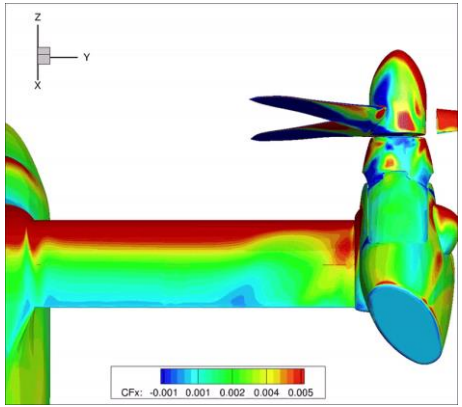


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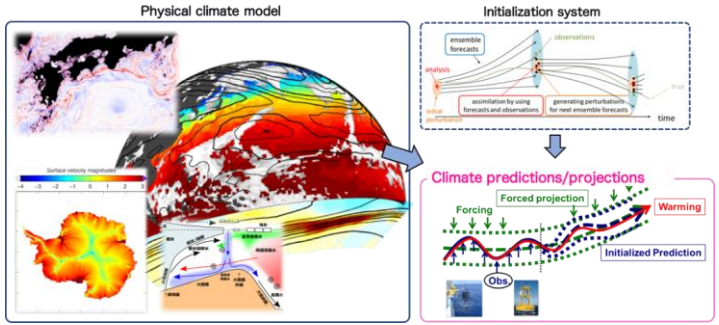


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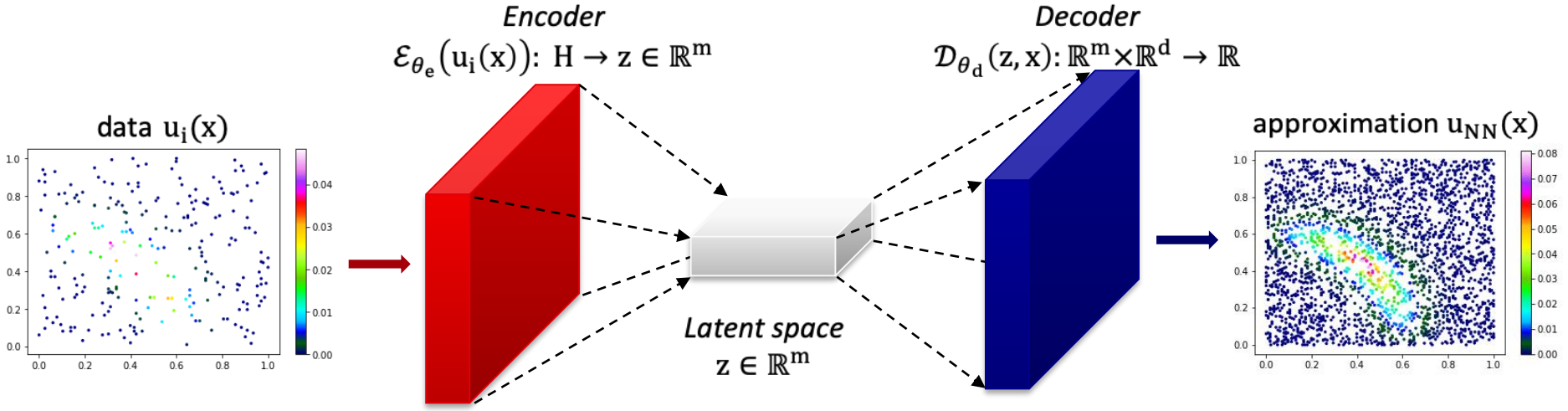
# Auto-encoder




- learning mappings between infinite-dimensional function spaces => mesh independent
- combining data-driven insights with traditional physics-based models
- inherently parallelizable and can run efficiently on GPUs which are key components of exascale systems

# Model Reduction

## Reduced Neural Galerkin algorithm

*"guessing" latent variable*

$z_0$

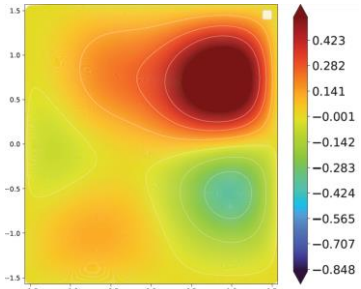
*Neural Galerkin algorithm*

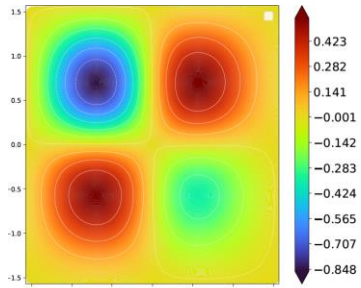
*"correct" latent variable*

$z_{NG}$

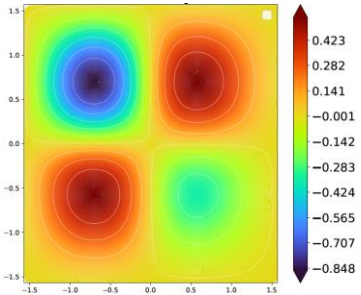
*Decoder*

$$\min_{z \in \mathbb{R}^m} \mathcal{L} u_{NN}(z) - f(u_{NN}(z))$$



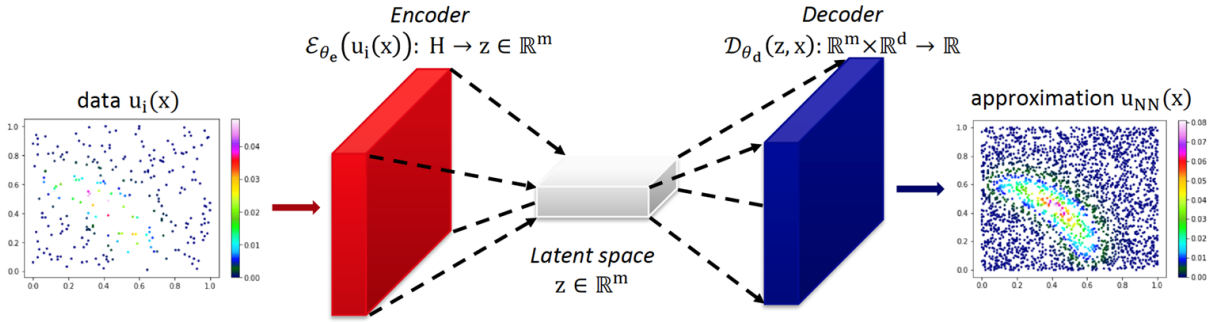




*Ground*



# Conclusions & Perspectives

- ✓ Auto-encoder for learning stationary PDEs
- ✓ Reduced Neural Galerkin (NG) algorithm for stationary problem and simple geometry




- ❑ Improving the learning process of the autoencoder
- ❑ Implementing Reduced NG algorithm for time depending problem and complex geometry

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