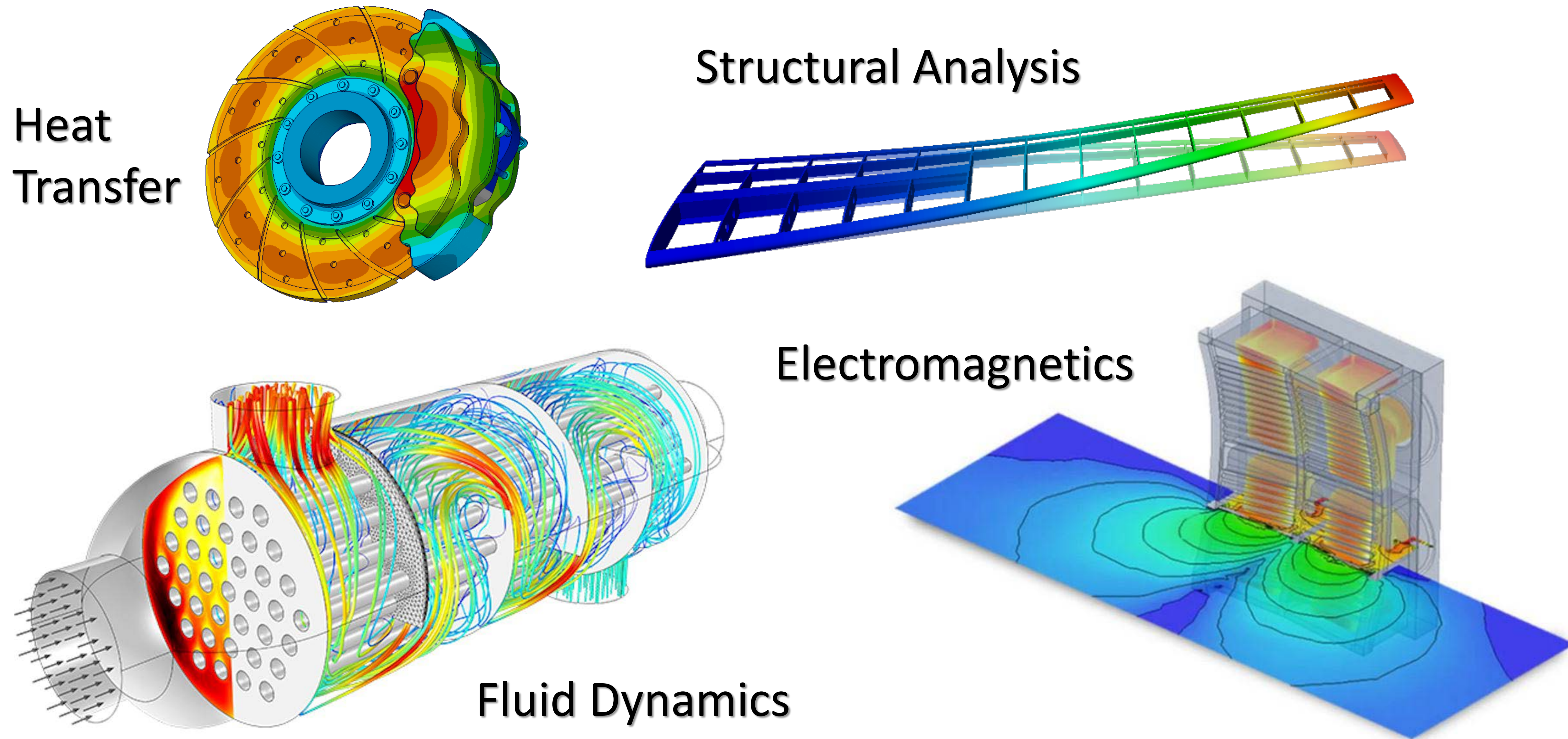# What is Physics-Informed Machine Learning (PIML)?
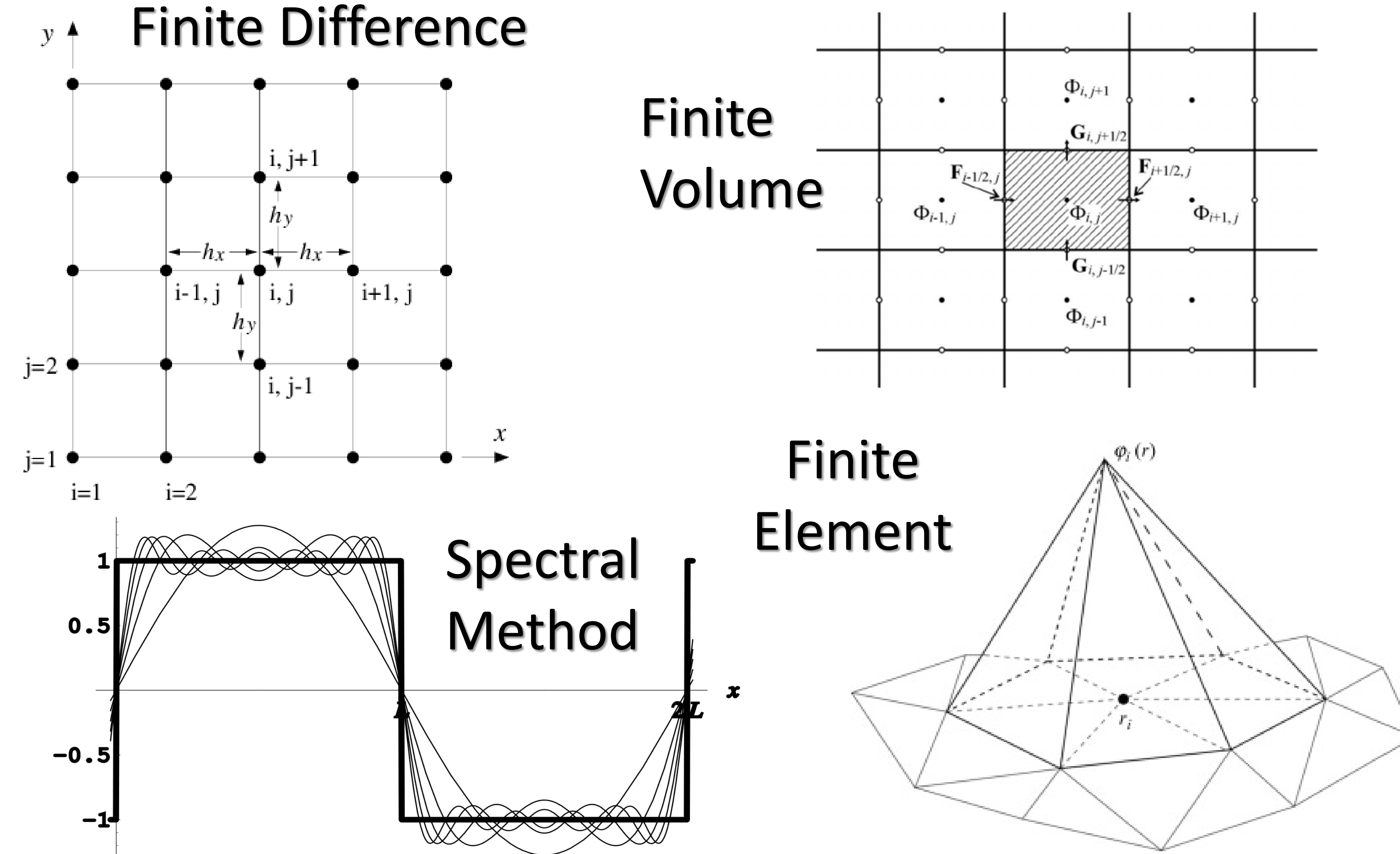
AI^2: Artificial Intelligence, Adaptation, and Innovation Group
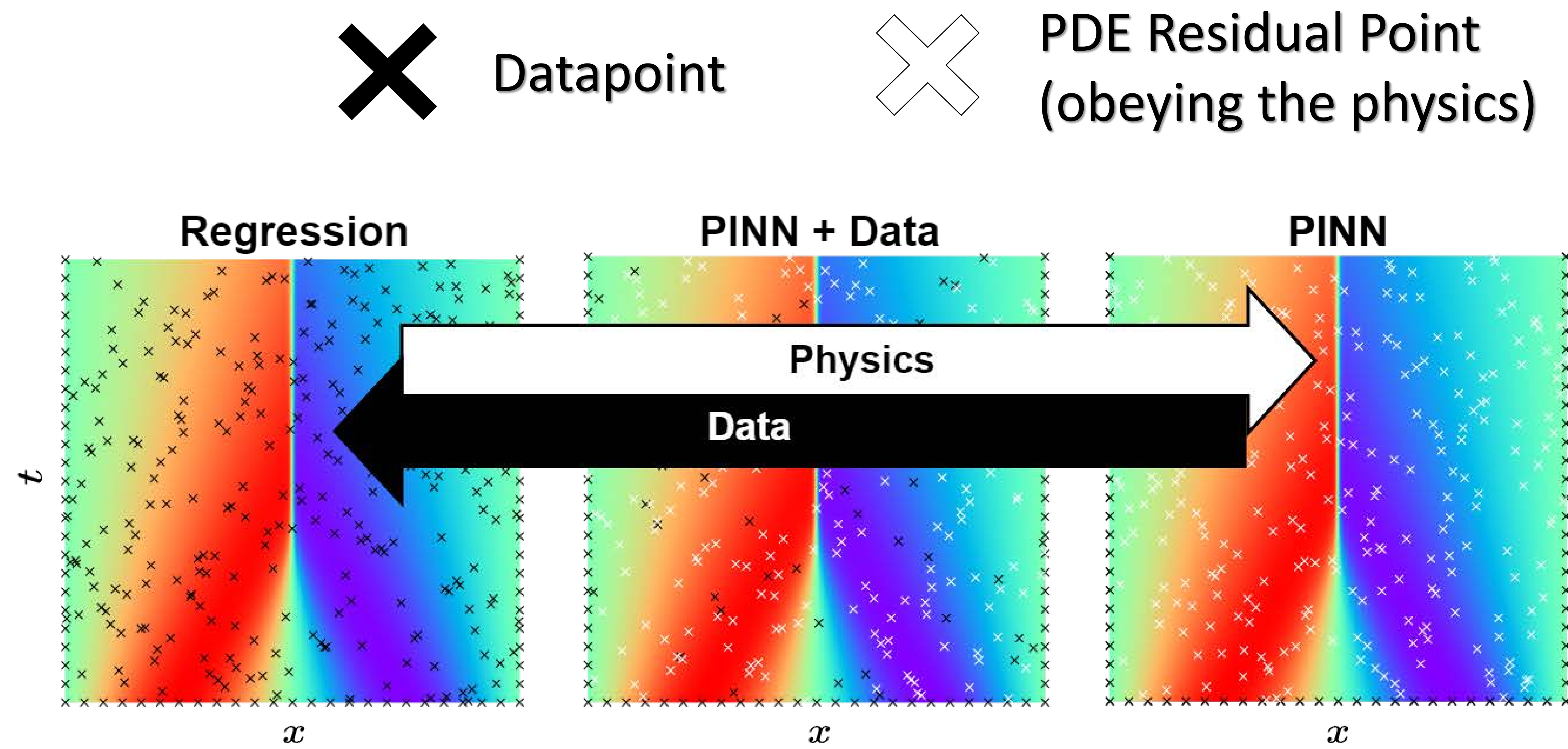

Solving Partial Differential Equations (PDEs): Why?

Heat Transfer

Structural Analysis

Electromagnetics

Fluid Dynamics

Traditional Approaches to Numerical Methods for PDEs

Finite Difference

Finite Volume

Spectral Method

Finite Element

Incorporating Physics into Neural Network Learning

✕ Datapoint

✕ PDE Residual Point (obeying the physics)

Regression

PINN + Data

PINN

Physics

Data

Physics-Informed Neural Networks (PINNs)

$NN(\mathbf{x}, t; \theta)$

$AD(\cdot)$

$PDE(\cdot)$

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial \mathbf{x}_i} - \frac{\partial^2 u}{\partial \mathbf{x}_i^2}$$

$\frac{\partial}{\partial t}$ $\frac{\partial}{\partial \mathbf{x}_i}$ $\frac{\partial^2}{\partial \mathbf{x}_i^2}$

$$\mathcal{L}(\mathbf{x}, t; \theta) = \lambda_{\mathcal{B}} MSE_{\mathcal{B}} + \lambda_{\mathcal{R}} MSE_{\mathcal{R}}$$

$$\theta^* = \arg\min_{\theta} \mathcal{L}(\mathbf{x}, t; \theta)$$

Optimization