



**PAV-IA**  
BEYOND INFORMAL AI TALKS

# PAV-IA Inaugural Lecture

## SIAM Student Chapter UniPV

**Francesco Regazzoni (MOX)**

**Integrating physics-based  
models with machine learning  
for fast and accurate  
simulations**



Mathematical models based on differential equations, such as Partial Differential Equations (PDEs) and Stochastic Differential Equations (SDEs), can yield quantitative predictions of physical processes. However, model development requires a deep understanding of the physical processes, that is not always available. Furthermore, the computational cost that accompanies the (possibly many-query) numerical approximation of such mathematical models may be prohibitive and hinder their use in relevant applications. In this talk, we present scientific machine learning methods that integrate physical knowledge with data-driven techniques to accelerate the evaluation of differential models and address many-query problems - such as sensitivity analysis, robust parameter estimation, and uncertainty quantification. To speed up input-output evaluations, we present Universal Solution Manifold Networks, namely emulators of differential models capable of predicting spatial outputs and accounting for the variability of the computational domain. Our method is based on a mesh-less architecture, thus overcoming the limitations associated with image segmentation and mesh generation required by traditional discretization methods, and encodes geometrical variability through an automatic shape encoding technique. Furthermore, we present Latent Dynamics Network, a space-time operator-learning method, which shows, tested in challenging problems, superior accuracy (normalized error 5 times smaller) with significantly fewer trainable parameters (more than 10 times fewer) than state-of-the-art methods. Numerical results demonstrate that these scientific machine learning methods enhance efficiency and accuracy in approximating quantities of interest, as well as in solving parameter estimation and uncertainty quantification problems.

**14/01/2025**  
**14:30-16:00**

Registration is free  
but mandatory!



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