THE UNIVERSITY OF CHICAGO | **THE COMMITTEE ON COMPUTATIONAL AND APPLIED MATHEMATICS**

COLLOQUIUM

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A Physics-Informed Data-Driven Algorithm for Ensemble Forecast of Complex Turbulent Systems

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Jones 303, 5747 S. Ellis Ave. Chicago, IL 60637

ABSTRACT

A new ensemble forecast algorithm, named as the physics-informed data-driven algorithm with conditional Gaussian statistics (PIDD-CG), is developed to predict the probability density functions (PDFs) of complex turbulent systems with partial observations. The PIDD-CG algorithm integrates a unique multiscale statistical closure modeling strategy with an extremely efficient nonlinear data assimilation scheme to create a mixture of conditional statistics. These conditional statistics serve as the forecast ensemble members to mitigate the curse of dimensionality in recovering high-dimensional PDFs. The multiscale features in the time evolution of these conditional statistics ensembles are effectively predicted by an appropriate combination of physics-informed analytic formulae and recurrent neural networks. An information metric is adopted as the loss function for the latter to more accurately capture the desirable turbulent features. The proposed algorithm succeeds in efficiently forecasting both the transient and statistical equilibrium non-Gaussian PDFs of strongly turbulent systems with intermittency, regime-switching, and extreme events. It also facilitates the development of efficient statistical reduced-order models in recovering and predicting the large-scale coherent structures of a large group of multiscale complex systems.

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