

PHYSICAL MATH SEMINAR

Making Sense from Sensitivity: Uncovering the Mechanisms Behind Extreme Events



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ABSTRACT:

Extreme events, such as earthquakes and coronal mass ejections, are common in high-dimensional chaotic dynamical systems, yet they are difficult to characterize and predict. Standard dimensionality reduction methods, such as PCA/POD, are based on reconstruction losses that favor large energetic structures, but in the process they discard dynamically relevant structures that nonlinear instabilities amplify into rare and extreme events. In this talk, we will show how gradient information from a quantity of interest reveals the dominant sensitive subspace, which we use to identify the mechanisms driving extreme events, build early-warning systems, and develop intuitive controllers that prevent them. We present results for identifying and suppressing mechanisms from a diverse set of systems, including turbulent bursts of energy dissipation, spontaneous synchronization in oscillator networks, and the formation of ocean rogue waves. Finally, we conclude by discussing approaches to uncover sensitive subspaces in experimental settings when gradients are not directly accessible.

Tuesday, October 6, 2026

2:30 PM – 3:30 PM

Building 2, Room 449