Physical Mathematics Seminar

From partial observations to long timescales through maximally predictive states

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ABSTRACT:

In many physical settings, isolating slower dynamics from fast fluctuations has proven remarkably powerful. But how do we proceed in complex systems when the underlying equations are unknown or uninformative? Here, we integrate information theory, dynamical systems and statistical physics to extract understanding directly from partial, dynamical, measurements. We introduce maximally predictive states, a symbolic, delay-embedded encoding constructed to maximize short-time predictive information. Transitions between these states yield a simple approximation of the transfer operator, which we use to reveal timescale separation and long-lived collective modes. Applicable to both deterministic and stochastic systems, we illustrate our approach through the the Lorenz system and the thermal dynamics of a particle in a double-well potential. Applied to the behavior of the nematode worm *C. elegans*, we bridge sub-second posture fluctuations and long range effective diffusion in foraging behavior, recovering the ``ballistic-to-diffusive" transition in the worm's centroid trajectories. Finally, we use our operator perspective to reveal long-lived "run-and-pirouette" behaviors, and to predict additional subtle subdivisions of the worm's "run" dynamics.

TUESDAY, SEPTEMBER 13, 2022
2:30 PM – 3:30 PM
Building 2, Room 449

http://math.mit.edu/seminars/pms/

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