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University of Miami, Physics Department Colloquium

Date: Wednesday, Feb 25, 2026
Time: 4:00 pm – 5:00 pm
Location: Physics Library – Rm 335, Knight Physics Building

Limits on the Computational Expressivity of Non-Equilibrium Biophysical Processes

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Abstract

Many biological decision-making tasks require classifying high-dimensional chemical states, and the biophysical and computational mechanisms that enable classification remain enigmatic. In this talk, I will first survey existing approaches to thinking about information processing through biochemical networks. Then, using Markov jump processes as an abstraction of general biochemical networks, I will discuss several newly discovered and universal limitations on the classification ability of generic biophysical processes. These limits arise from a fundamental non-equilibrium thermodynamic constraint that we have derived. Importantly, I will discuss how these limitations can be overcome using common biochemical mechanisms that we term input multiplicity, examples of which include enzymes acting on multiple targets. Analogous to how increasing depth enhances the expressivity and classification ability of neural networks, this work demonstrates how tuning input multiplicity can potentially enable an exponential increase in a biological system's ability to classify and process information. I will end by discussing preliminary generalizations to non-linear chemical reaction networks and applications to specific biological coding problems.