PHYSICAL MATHEMATICS SEMINAR

Spatiotemporal dynamics in neural systems: from data to mathematical models and computation

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ABSTRACT:

Neurons in cortex are connected in intricate patterns, with local- and long-range connections and time delays for transmitting signals. In recent work, we have found that spontaneous and stimulus-driven waves travel over these networks, changing excitability of the neurons and shaping perceptual sensitivity. Understanding how these networks generate these sophisticated dynamics, however, remains an open problem. This is due, in part, to the fact that connecting the specific structure of networks to the nonlinear dynamics that will result is a difficult problem in general. Further, experiments suggest one mechanism for these waves could be the distance-dependent time delays due to transmitting spikes along the axons connecting neurons across these networks. Analyzing the underlying network mechanism for these waves thus represents an additional challenge, as we need to consider systems with many time delays.

In this talk, I will present recent results from my group connecting the structure of individual networks to the resulting dynamics in systems of nonlinear Kuramoto oscillators. We introduce a complex-valued approach that allows connecting the eigenspectrum of the graph adjacency matrix to the nonlinear dynamics that result in individual simulations of these systems. This approach allows predicting the specific spatiotemporal pattern that will result from the connectivity pattern in an individual network. An extension of this approach allows predicting the specific spatiotemporal patterns generated by distance-dependent time delays from spike transmission in these systems. Finally, I will present our latest efforts to understand computation with spatiotemporal dynamics in neural systems using these nonlinear network models.

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2:30 PM – 3:30 PM
Building 2, Room 449

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