Speaker: David CLARK

Title: **Statistical-Physics Approaches to Understanding Activity Structure and Dynamics in Large Recurrent Neural Networks**

Abstract: Neural circuits are high-dimensional nonlinear dynamical systems that process information through the coordinated activity of many connected units. Understanding these networks is a major challenge in theoretical neuroscience. I will describe various works that approach this challenge using statistical-physics tools. First, I will present a random-network model that captures the modular organization of real neural circuits by implementing "communication subspaces" between cortical areas, motivated by experimental studies. A dynamical mean-field theory is developed to analyze the interaction between high-dimensional fluctuations within regions and low-dimensional signal transmission between regions. While neuron-to-neuron interactions are usually modeled as having vector dynamics shaped by a matrix, in this mean-field theory, region-to-region interactions have matrix dynamics shaped by a third-order tensor. Next, I will discuss a theory that goes beyond traditional mean-field approaches to capture population-level features of neural activity, such as its dimensionality. This theory is used to probe spatiotemporal features of activity coordination in a random-network model with independent and identically distributed couplings, showing an extensive but fractionally low effective dimension of activity and a long population-level timescale. An extension of this model to describe networks with low-rank structure in the weights will also be presented.