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THE HONG KONG UNIVERSITY OF SCIENCE & TECHNOLOGY

Department of Mathematics

SEMINAR ON APPLIED MATHEMATICS

A non-perturbative renormalization group analysis of stochastic spiking networks

By

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Abstract

The critical brain hypothesis posits that neural circuits may operate close to critical points of a phase transition, which has been argued to have functional benefits for neural computation. Theoretical and computational studies arguing for or against criticality in neural dynamics have largely relied on establishing power laws in neural data, while a proper understanding of critical phenomena requires a renormalization group (RG) analysis. However, neural activity is typically non-Gaussian, nonlinear, and non-local, rendering models that capture all of these features difficult to study using standard statistical physics techniques. We overcome these issues by adapting the non-perturbative renormalization group (NPRG) to work on network models of stochastic spiking neurons. Within a ``local potential approximation," we are able to calculate non-universal quantities such as the effective firing rate nonlinearity of the network, allowing improved quantitative estimates of network statistics. We then show which properties of the synaptic connectivity shape "universal" quantities like the exponents of power-law behavior at the critical point. As an example, we consider spontaneously active networks, whose exponents are found to be in the universality class of the Ising model.

Bio

Dr. Brinkman did his Ph.D. in non-equilibrium statistical physics at the University of Illinois, and transitioned into theoretical neuroscience during his postdoc at the University of Washington. He started as an assistant professor at Stony Brook University in 2018. His current research leverages his statistical physics background to study how the collective dynamics of neurons enable the brain to represent, transmit, and combine information across a larger range of spatial and temporal scales than any individual neuron can access. He is especially interested in elucidating how network structure and dynamics determine a circuit’s computational capabilities, and how pathologies in structure or dynamics may manifest as diseases like epilepsy—and how we might be able to use our theoretical frameworks to design principled interventions to treat diseased networks.

Date : 19 December 2024 (Thursday)

Time : 2:00p.m. – 3:00p.m.

Venue : Room 5583 (near Lift 31/32)

All are Welcome!