THE BRAHMAGUPTA PHYSICS COLLOQUIUM

Can machines learn physics?

Ayana Ghosh, IIT Madras

Emergent phenomena arise when competing microscopic interactions collectively shape the behavior of complex systems, often producing properties that cannot be understood from any single interaction alone. Harnessing these emergent responses is central to developing materials for applications ranging from energy and information technologies to sensing and quantum devices. In this talk, I will discuss how theory, computation combined with machine learning (ML) can uncover the mechanisms governing functional properties, moving beyond prediction toward mechanistic understanding. This will be illustrated through examples from complex oxides and two-dimensional materials, where physically informed representations are used to reveal how competing structural, electronic and magnetic interactions govern functional responses while uncovering pathways for controlling material properties. Emphasis will be placed on incorporating physical principles and domain knowledge into ML models, enabling them to learn beyond correlations toward physically meaningful relationships governed by underlying mechanisms. Such physically grounded models can also provide a bridge to experiment by interpreting measurements and guiding what to measure next, paving the way toward autonomous experiments that accelerate the discovery and control of emergent functionality.

Dr. Ghosh is an Assistant Professor in the Department of Physics at IIT Madras. Prior to joining IIT Madras, she was a Staff Scientist at **Oak Ridge National Laboratory (ORNL)**, following her postdoctoral research there. She received her **PhD in Materials Science and Engineering from the University of Connecticut** in 2020 and her **BS in Physics and Abstract Mathematics from the University of Michigan** in 2015. Her research lies at the intersection of materials physics, computational physics, machine learning, and autonomous experimentation, with a focus on understanding emergent phenomena by connecting microscopic theory with experimental observations across complex oxides, two-dimensional systems, and hybrid materials. She has authored over 50 peer-reviewed publications and delivered invited talks at major international conferences in physics and materials science. Her recent honors include the **ORNL Director's Award** (2024), **ORNL Early Career Research Accomplishment Award** (2024), the **Early Discovery Award** (2024) from the American Ceramic Society, and recognition as a **Rising Star in Computational and Data Sciences** (2022) at Sandia National Laboratories.

Venue: HSB 209 (PH Seminar Hall)
Time: 4:30 - 5:30 PM

Wednesday August 12, 2026
Cake at 4:15 PM

DEPARTMENT OF PHYSICS
INDIAN INSTITUTE OF TECHNOLOGY MADRAS