Title: Advanced Computational Electromagnetics: Beyond the Standard Numerical Modeling Techniques

Abstract:

Computational Electromagnetics (CEM) is an interdisciplinary field that combines principles from electrical engineering, physics, mathematics, and computer science to simulate and analyze electromagnetic phenomena. It serves as a cornerstone for the design and optimization of practical systems such as antennas, microwave circuits, radars, satellites, wireless communication devices, and emerging applications in nanophotonics and biomedical imaging. The increasing complexity of modern systems—featuring irregular geometries, inhomogeneous media, and multiscale behaviors—necessitates robust and efficient modeling and simulation techniques.

Over the past decades, CEM has evolved to address challenges associated with electrically large structures, multiphysics environments, and high-frequency regimes. Recent advancements in computing technologies—especially GPUs and domain-specific hardware—have enabled researchers to solve problems with billions of unknowns, while hybrid numerical schemes and parallel implementations ensure scalability and efficiency. Recent trends also include the use of machine learning-based surrogate models, which are trained to approximate the behavior of computationally expensive simulations, enabling faster predictions without compromising accuracy.

This lecture will present advanced techniques used to tackle contemporary challenges in CEM, such as hybrid methods, domain decomposition, and large-scale parallel solvers. Current trends that are reshaping the future of the field—such as the integration of data-driven machine learning approaches into electromagnetic modeling workflows—will be briefly highlighted. Real-world case studies will be presented to illustrate the practical applications of these methods in the simulation of electromagnetic radiation and scattering problems.