Contribution ID: **113**   Type: **Talk**

Active Physics-Informed Deep Learning for Topological Nanophotonics under Nonplanar Excitation

Friday 19 September 2025 11:30 (12 minutes)

Topological nanophotonic systems offer robust light propagation modes with immunity to defects, holding promise for quantum technologies and advanced optical devices.[1] However, designing such structures under nonplanar excitation remains computationally intensive due to high-dimensional design spaces and nonlinear interactions. I introduce a physics-informed deep learning framework that integrates physical constraints into surrogate modeling to accelerate the design of topological plasmonic devices.[2] My approach reduces simulation requirements by 50–70% compared to conventional data-driven methods while ensuring physical consistency. Using a three-stage training strategy, the model predicts strong versus weak coupling regimes, identifies topological phases in Su-Schrieffer-Heeger (SSH) chains, and optimizes ring geometries for unidirectional edge mode propagation under nonplanar wavefront excitations. The framework successfully designs a nanohole-based SSH ring resonator supporting robust one-way plasmonic edge modes at 378 THz, resilient to structural defects. This work demonstrates how combining machine learning with physics principles enables scalable, resource-efficient design of topologically protected photonic devices, paving the way for next-generation nanophotonics and integrated quantum systems.[3]

Keywords: topological photonics, physics-informed machine learning, plasmonics, surrogate modeling, nonplanar excitation

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Session Classification: Parallel

Track Classification: Quantum Effects, Materials Physics