HAMLET
How to Apply Machine Learning to Experimental & Theoretical PHYSICS
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# Machine Learning and Quantum Field Theory: a two-way dialogue

*Wednesday 20 August 2025 11:05 (25 minutes)*

Quantum Field Theory (QFT) and modern Machine Learning (ML) share deep structural analogies, from path integrals and renormalization to latent spaces and marginalization. With its solid theoretical foundation, QFT offers a powerful lens to interpret global behaviors in ML that remain poorly understood. This talk explores the interplay between QFT and ML in both directions.
In QFT, the only systematically-improvable, first-principles approach is Lattice QFT, based on evaluating the path integral using MCMC algorithms which remains the state-of-the-art. Recently, architectures based on Normalizing Flows (NF) have been proposed to enhance or even replace these methods. We will show how ML can help address the long-standing signal-to-noise degradation problem in Lattice QFT by combining NF with stochastic automatic differentiation.
Conversely, we discuss how QFT provides a controlled environment to explore core ML concepts. In particular, we present a generative stochastic autoencoder trained to perform a Super Resolution task on field configurations, where notions like depth, latent structure, and resolution enhancement emerge in a physically meaningful context.

## Broad physics domain

Stochastic numerical methods for quantum field theory on the lattice

## AI/ML technique(s) to be presented

Stochasting autoencoders, Super Resolution networks, Gauge-equivariant (continuous) normalizing flows, (neural ODEs)

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