Machine learning approaches in Lattice QCD - an interdisciplinary exchange



Report of Contributions

Welcome

Contribution ID: 1

Type: not specified

Welcome

Tuesday 10 June 2025 09:50 (10 minutes)

Presenter: KRSTIC MARINKOVIC, Marina (ETH Zurich)

Optimal transport for anomaly d \cdots

Contribution ID: 2

Type: not specified

Optimal transport for anomaly detection at LHC

Tuesday 10 June 2025 10:00 (50 minutes)

Presenter: HOWARD, Jessica N. (Kavli Institute for Theoretical Physics)

Machine learning RG-improved S ...

Contribution ID: 3

Type: not specified

Machine learning RG-improved SU(3) gauge actions

Tuesday 10 June 2025 11:30 (50 minutes)

I describe how RG-improved SU(3) gauge actions can be parametrized through machine learning gauge covariant convolutional neural networks. I discuss how the approach benefits from the straightforward accessibility of gauge field derivatives and the capability to generate targeted learning.

Presenter: WENGER, Urs (University of Bern)

Stochastic differentiation of Mon ...

Contribution ID: 4

Type: not specified

Stochastic differentiation of Monte Carlo simulations for parameter inference in quarkonium suppression

Tuesday 10 June 2025 14:00 (35 minutes)

In many scientific domains, phenomena are being described by demanding Monte Carlo simulations. A common problem setting is that these simulations depend on input parameters, whose values are a priori not clear. To determine the input parameters one usually falls back to fitting the output of the simulator to some target. This can become particularly challenging, when the simulator is expensive to evaluate and the number of input parameters increases. In this talk I will discuss the approach of differentiating the simulator, which enables parameter inference by gradient descent. For Monte Carlo simulations involving discrete probabilities it is possible to build on the REINFORCE gradient estimator to differentiate the full stochastic simulation. I demonstrate this method for the simulation of quarkonium suppression. Quarkonium suppression refers to the phenomenon of bound states dissociating in the quark gluon plasma and can be measured by the nuclear modification factor R_{AA} . The underlying simulator that predicts this suppression solves a Lindblad equation by sampling stochastic trajectories. I showcase how to obtain a low variance gradient estimator and fit the quarkonium transport coefficients to nuclear modification factor data.

Presenter: MAGORSCH, Tom

Optimizing static quark states wi ...

Contribution ID: 7

Type: not specified

Optimizing static quark states with Neural Network parametrized general Wilson loops

Tuesday 10 June 2025 14:35 (35 minutes)

Presenter: MAYER-STEUDTE, Julian

Protecting continuum symmetries ···

Contribution ID: 8

Type: not specified

Protecting continuum symmetries on the lattice exact prior information for reinforcement learning

Tuesday 10 June 2025 15:40 (50 minutes)

Presenter: Prof. ROTHKOPF, Alexander (Korea University)

Discussion

Contribution ID: 9

Type: not specified

Discussion

Tuesday 10 June 2025 16:30 (45 minutes)

Presenter: BRAMBILLA, Nora

Monte Carlo estimates of flow fie \cdots

Contribution ID: 10

Type: not specified

Monte Carlo estimates of flow fields for sampling and noise problems

Wednesday 11 June 2025 10:00 (35 minutes)

Presenter: KANWAR, Gurtej (University of Edinburgh)

Applications of flow models to the …

Contribution ID: 11

Type: not specified

Applications of flow models to the generation of correlated lattice QCD ensembles

Wednesday 11 June 2025 11:20 (50 minutes)

Machine-learned normalizing flows can be used in the context of lattice quantum field theory to generate statistically correlated ensembles of lattice gauge fields at different action parameters. In this talk, we show examples on how these correlations can be exploited for variance reduction in the computation of observables. Different proof-of-concept applications are presented: continuum limits of gauge theories, the mass dependence of QCD observables, hadronic matrix elements based on the Feynman-Hellmann approach, and the computation of glueball correlators. In all cases, statistical uncertainties are significantly reduced when machine-learned flows are incorporated as compared with the same calculations performed with uncorrelated ensembles or direct reweighting.

Presenter: ROMERO LÓPEZ, Fernando

Contribution ID: 12

Type: not specified

Applications of Stochastic Normalizing Flows to gauge theories and defects

Wednesday 11 June 2025 13:50 (35 minutes)

In recent years, flow-based samplers have emerged as a promising alternative to standard sampling methods in lattice field theory. In this talk, I will introduce a class of flow-based samplers known as Stochastic Normalizing Flows (SNFs), which are hybrid algorithms combining neural networks and non-equilibrium Monte Carlo methods. I will then demonstrate that SNFs exhibit excellent scaling with volume in lattice SU(3) gauge theory. Afterward, I will discuss theories with defects and present a general strategy for applying flow-based samplers to such systems. In particular, I will showcase an application of our approach to scalar field theory for calculating entanglement entropy, as well as an application to SU(3) gauge theory aimed at addressing topological freezing.

Presenter: CELLINI, Elia (University of Turin / INFN Turin)

Application of generative models ···

Contribution ID: 13

Type: not specified

Application of generative models on SU(3) gauge theories in 4 dimension

Wednesday 11 June 2025 14:25 (35 minutes)

Presenter: KOMIJANI, Javad (ETH Zurich)

Score-Based Diffusion Models for …

Contribution ID: 14

Type: not specified

Score-Based Diffusion Models for Lattice Gauge Theory

Wednesday 11 June 2025 16:40 (35 minutes)

Presenter: VEGA, Octavio

Machine learni $\ \cdots \ /$ Report of Contributions

Discussion

Contribution ID: 15

Type: not specified

Discussion

Wednesday 11 June 2025 15:40 (1 hour)

Presenters: KRSTIC MARINKOVIC, Marina (ETH Zurich); Prof. RYAN, Sinead (Trinity College Dublin)

Progress in learning contour defo ...

Contribution ID: 16

Type: not specified

Progress in learning contour deformations for observables

Thursday 12 June 2025 10:00 (50 minutes)

Presenter: DETMOLD, William

Diffusion models for lattice field t

Contribution ID: 17

Type: not specified

Diffusion models for lattice field theory

Thursday 12 June 2025 11:30 (50 minutes)

Presenter: Prof. AARTS, Gert (Swansea University)

Machine Learning Low-D Systems

Contribution ID: 18

Type: not specified

Machine Learning Low-D Systems

Thursday 12 June 2025 13:50 (50 minutes)

I discuss how machine learning is used in stochastic simulations of low-D strongly correlated systems. In particular, I show how machine learning is used to alleviate the numerical sign problem in systems that are doped and/or non-bipartite. I further discuss how flow-based generative models can be used to address ergodicity issues in low-D simulations. Finally, I argue that low-D systems offer a great testbed for testing novel algorithms that could potentially be used in lattice gauge theory simulations.

Presenter: Prof. LUU, Thomas (Forshungszentrum Jülich)

Simulations of machine-learned ····

Contribution ID: 19

Type: not specified

Simulations of machine-learned RG-improved SU(3) gauge action

Thursday 12 June 2025 14:40 (35 minutes)

Presenter: HOLLAND, Kieran

Stochastic automatic differentiati ...

Contribution ID: 20

Type: not specified

Stochastic automatic differentiation for Lattice QCD

Thursday 12 June 2025 16:20 (50 minutes)

Presenter: RAMOS MARTINEZ, Alberto (Univ. of Valencia and CSIC (ES))

Discussion

Contribution ID: 21

Type: not specified

Discussion

Thursday 12 June 2025 17:10 (45 minutes)

Presenter: KRONFELD, Andreas (Fermi National Accelerator Lab. (US))

Random Matrix Theory for a nano- ···

Contribution ID: 22

Type: not specified

Random Matrix Theory for a nano-GPT

Friday 13 June 2025 10:00 (35 minutes)

Presenter: HAJIZADEH, Ouraman (Independent Researcher)

Optimized Multi-Grid Solvers: Po

Contribution ID: 23

Type: not specified

Optimized Multi-Grid Solvers: Power, Precision, and (Matrix) Products

Friday 13 June 2025 10:35 (50 minutes)

Presenter: WEINBERG, Evan (NVIDIA Corporation)

Recent Performance Using MILC ····

Contribution ID: 24

Type: not specified

Recent Performance Using MILC and QUDA on Various GPU Systems

Friday 13 June 2025 11:55 (50 minutes)

I plan to show performance data for the MILC code calling QUDA for configuration generation. There will be a combination of benchmark runs and production runs on various systems. I will also show some recent results for deflation, multigrid, and gauge flow performed by Leon Hostetler with the assitance of Evan Weinberg. If there is time I will discuss some work to prepare for a new ensemble with a lattice spacing of about 0.03 fm and physically light quarks.

Presenter: GOTTLIEB, Steven

Machine learni $\ \cdots \ /$ Report of Contributions

Closing

Contribution ID: 25

Type: not specified

Closing

Friday 13 June 2025 12:45 (15 minutes)

Presenter: KRSTIC MARINKOVIC, Marina (ETH Zurich)

Contribution ID: 26

Type: not specified

Efficient Multilevel Sampling of Lattice Field Theory Near Criticality

Thursday 12 June 2025 15:45 (35 minutes)

We present a hierarchical generative framework for efficient sampling of scalar field configurations near criticality. The method leverages a multiscale structure where coarse and intermediate fields are sampled via conditionally constructed Gaussian Mixture Models (GMMs). Normalizing Flows (NFs) refine these samples through invertible transformations that match the target distribution. This approach enables high Effective Sample Size (ESS) and mitigates critical slowing down. Our results demonstrate improved scalability and accuracy over traditional and superresolution-based methods.

Presenter: SINGHA, Ankur