Contribution ID: **207** Type: **Talk without Poster**

Improved Fixed Point Actions from Gauge Equivariant Neural Networks

Thursday, 2 May 2024 16:00 (20 minutes)

Gauge symmetry is fundamental to describing quantum chromodynamics on a lattice. While the local nature of gauge symmetry presents challenges for machine learning due to the vast and intricate parameter space, which involves distinct group transformations at each spacetime point, it remains a fundamental and indispensable prior in physics. Lattice gauge equivariant convolutional neural networks (L-CNNs) can be utilized to approximate any gauge-covariant function in a robust way [1].

Here we apply L-CNNs to learn the fixed point (FP) action, implicitly defined through a renormalization group transformation [2]. FP actions, designed to be free of lattice artifacts on classical gauge-field configurations, can yield quantum physical predictions with greatly reduced lattice artifacts, even on coarse lattices. Training L-CNNs, we obtain an FP action for SU(3) gauge theory in four dimensions which significantly exceeds the accuracy of previous hand-crafted parametrizations. This is a first step towards future Monte Carlo simulations that are based on machine-learned FP actions, which have the potential to avoid typical problems such as critical slowing down and topological freezing.

[1] M. Favoni, A. Ipp, D. I. Müller, D. Schuh, Phys. Rev. Lett. 128 (2022), 032003, https://doi.org/10.1103/PhysRevLett.128.032003 , https://arxiv.org/abs/2012.12901

[2] K. Holland, A. Ipp, D. I. Müller, U. Wenger, https://arxiv.org/abs/2401.06481

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Session Classification: 5.2 Physics-informed AI & Integration of physics and ML