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The 225th HENPIC seminar by Longgang Pang (庞龙刚)，CCNU(华中师大)，April 03-2025, Thursday, 10:30am (Beijing time)

Title: Bridging Physical Simulations of Heavy Ion Collisions with AI for Scientific Discovery

Abstract:

Relativistic heavy-ion collisions recreate an exotic state of nuclear matter—the quark-gluon plasma (QGP)—mirroring the primordial matter that permeated the universe within its first microseconds after the Big Bang. This extreme state of matter exhibits extrodinary properties: it is the hottest substance ever created on Earth, hosts record-breaking vorticity and magnetic fields, and approaches the theoretical limit of minimal viscosity ($\eta/s \sim 1/4\pi$). Despite its fleeting lifetime (~10^{-23} seconds), the QGP encodes profound insights into fundamental physics, accessible through the momentum distribution of final-state hadrons. These observables unveil critical features of quantum chromodynamics (QCD), including the phase structure, equation of state, transport coefficients, and the initial-state nuclear configurations. In this talk, I will present our recent work at the intersection of high-energy nuclear physics and artificial intelligence. We leverage AI to revolutionize scientific inquiry across multiple frontiers:
- Solving inverse problems to reconstruct the QGP properties and the initial state of HICs,
- Designing physics-informed neural networks for effective theory in QCD,
- Simulating medium response dynamics with unprecedented precision,
- Developing large language model (LLM) agents to automate and enhance scientific workflows.
This interdisciplinary study bridges computational physics and machine learning, opening new paradigms for understanding strongly coupled quantum systems.

Brief introduction about the speaker:

Dr. Long-Gang Pang is a Professor at Central China Normal University, specializing in high-energy nuclear physics and AI-driven scientific computing. He earned his B.Sc. in Physics from the University of Science and Technology of China (USTC) in 2006 and completed his Ph.D. at USTC in 2012 under a joint program with Lawrence Berkeley National Laboratory (LBNL, U.S.), supported by the Chinese Government Scholarship. Following postdoctoral research at the Institute of Particle Physics (China) and appointments at the Frankfurt Institute for Advanced Studies (Germany) and UC Berkeley (U.S.), he joined Central China Normal University in 2019.

Dr. Pang has spearheaded the development of CLVisc, a GPU-accelerated (3+1)-dimensional relativistic viscous hydrodynamic code for simulating the spatiotemporal evolution of QGP in heavy-ion collisions. He contributed to the SMASH (Simulating Many Accelerated Strongly-interacting Hadrons) transport model and pioneered AI applications in nuclear physics, including Bayesian inference, deep learning-enhanced QGP tomography, and LLM-based research automation. His current focus are:
- Next-generation hydrodynamic code CLVisc 3.0
- AI-powered frameworks for solving inverse, variational, and generative challenges in QGP physics
- LLM agents for accelerating scientific discovery and education

Summary

Presenter: Prof. PANG, Longgang (CCNU)