Theoretical and Computational Physics highlights in December, 2023

APS J. J. and NORIKO SAKURAI DISSERTATION AWARD IN THEORETICAL PARTICLE PHYSICS

Dr. Zhite Yu received the APS 2024 J. J. and Noriko Sakurai Dissertation Award in Theoretical Particle Physics with the citation, *"For discovering new jet polarization substructures resulting from quantum interference at high-energy colliders, advancing the QCD factorization for exclusive processes, and offering innovative solutions to the enduring x-dependence problem of generalized parton distributions."*

THE EXASCALE COMPUTING PROJECT

Dr. Robert Edwards served as co-PI for the Exascale Computing Project. Over seven years, the Project has fostered a unique collaboration of domain scientists, applied math, computer science, and industrial partners to develop a software ecosystem for exascale. The project finished in Dec. 2023, meeting its milestones, and significantly accelerating the pace of nuclear science with deployment on the new Frontier and Aurora computing systems.

TOWARD A GENERATIVE MODELING ANALYSIS OF CLAS EXCLUSIVE 2π PHOTOPRODUCTION

A team of theoretical and experimental nuclear physicists and data scientists at Jefferson Lab explored the use of AI-supported generative modeling to unfold detector effects from an exclusive reaction involving multi-particle final states [Phys. Rev. D108 (2023) 094030]. A full closure test performed with Monte Carlo simulations of the $\gamma p \to p\pi\pi$ reaction in the kinematics of the CLAS g11 experiment demonstrated the preservation of correlations between kinematic variables in a multidimensional phase space. Two sets of generative adversarial networks (GANs) were deployed. The first neural network (NN), trained on MC pseudo-data passed through GEANT simulations of the CLAS detector, learned the detector response, while the second NN was used to unfold detector effects. The comparison between the generated pseudo-data and the synthetic copy provided by the GAN showed excellent agreement within the uncertainties. The test demonstrates that GANs can reproduce highly correlated multidifferential cross sections even in the presence of detector-induced distortions in the training datasets, and provides a basis for applying the framework to real experimental data.

COHERENT QUANTUM COMPUTATION OF SCATTERING AMPLITUDE

A new paper [arXiv:2312.12613] by Dr. Robert Edwards and collaborators discusses the feasibility of using quantum optical simulation to study scattering observables presently inaccessible via lattice QCD, and are at the core of the experimental program at Jefferson Lab, the future EIC, and other accelerator facilities. The study shows how recent progress in measurement-based photonic quantum computing can be leveraged to provide deterministic generation of required exotic gates and implementation in a single photonic quantum processor.