Theoretical and Computational Physics highlights in June 2024

$\pi^+\pi^-$ photoproduction beyond Pomeron exchange

Based on an analysis of CLAS photoproduction data, a new JPAC analysis [arXiv:2406.08016] showed that dynamics of two-pion photoproduction for four-momentum transfers above 0.5 GeV^2 cannot be explained by Pomeron exchange alone. This motivated the development of a new theoretical model of two-pion photoproduction that incorporates both two-pion and pion-nucleon resonant contributions. The model provides an excellent description of the low moments of the angular distribution measured at CLAS and enables an assessment of the relative contributions of particular production mechanisms.

Pion loop contributions to generalized parton distributions at nonzero skewness

In a new theoretical analysis [arXiv:2406.03412] Dr. Wally Melnitchouk and colleagues computed the one-loop contributions to spin-averaged generalized parton distributions in the proton from pseudoscalar mesons with intermediate octet and decuplet baryon states at nonzero skewness. The framework is based on nonlocal covariant chiral effective theory with the splitting functions calculated from the nonlocal Lagrangian. The analysis found the nonzero skewness GPDs from meson loops by convoluting with the phenomenological pion GPD and the generalized distribution amplitude, and computed the meson loop effects on the Dirac, Pauli and gravitational form factors of the proton.

Coupled-channel J^{--} meson resonances from lattice QCD

Understanding the spectrum of excited vector meson resonances both in theory and in experiment remains a challenge. In a new paper [arXiv:2406.07261], Dr. Jo Dudek and colleagues reports on a lattice QCD calculation of several states with $\mathrm{J}^{\mathrm{PC}} = 1^{--}$, 2^{--}, 3^{--} quantum numbers appearing in pseudoscalar-pseudoscalar and pseudoscalar-vector scattering. Consequences of the first-principles QCD results for our understanding of the physical $\rho^*\mathrm{J}$, $\mathrm{K}^*\mathrm{J}$, $\omega^*\mathrm{J}$ and $\phi^*\mathrm{J}$ resonances are presented.

Inclusive reactions from finite Minkowski spacetime correlation functions

A new Theory paper [arXiv:2406.06877] studies a recently proposed estimator for studying scattering processes directly from real-time correlation functions, which may be accessible in the near future using quantum computers or tensor networks. In particular, further empirical evidence was found that these estimators provide a systematically improvable determination of a wider class of reactions than previously considered. Order of magnitude estimates are also provided for spacetime volume sizes that the real-time correlators must satisfy to accurately reproduce physical amplitudes.

Thermal state preparation of the SYR model using a variational quantum algorithm

Dr. Felix Ringer and collaborators studied [arXiv:2406.15545] the preparation of thermal states of the dense and sparse Sachdev-Ye-Kitaev (SYK) model using a variational quantum algorithm for $6 \leq N \leq 12$ Majorana fermions over a wide range of temperatures. Utilizing IBM's 127-qubit quantum processor, they performed benchmark computations for the dense SYK model with N=6, showing good agreement with exact results. The preparation of thermal states of a non-local random Hamiltonian with all-to-all coupling using the simulator and quantum hardware represents a significant step toward future computations of thermal out-of-time order correlators in quantum many-body systems.