**Theoretical and Computational Physics highlights in October 2024**

**Heavy flavor jet substructure**

The Dead-cone effect is a general property of gauge theories, which consists of the suppression of collinear radiation around massive radiators, and may affect the substructure of jets seeded by massive quarks (such as charm or bottom). A new paper [arXiv:2410.05415] by Dr. Oleh Fedkevych and collaborators provides the necessary ingredients for a next-to-leading-log accuracy calculation of jet substructure observables, such as energy-energy correlation functions and jet angularities, for jets seeded by massive quarks, and studies the impact of the Dead-cone effect on the distribution of particles inside the jets. The paper also discusses the impact of nonperturbative corrections such as hadronization and underlying event contributions, with particular emphasis on effects due to B-hadron decays.

**Toward hybrid quantum simulations with qubits and qumodes on trapped-ion platforms**

Drs. Felix Ringer, Jack Araz and collaborators explored the feasibility of hybrid quantum computing with discrete (qubit) and continuous (qumode) variables on trapped-ion platforms. Using numerical simulations, they showed [arXiv:2410.07346] that high-fidelity hybrid gates and measurement operations can be achieved for existing trapped-ion quantum platforms. As an exemplary application, the Jaynes-Cummings-Hubbard model was considered, which provides a starting point for future quantum simulations of lattice field theories involving both fermion and gauge field degrees of freedom.

**Quantum computation of SU(2) lattice gauge theory with continuous variables**

A collaboration by Drs. Felix Ringer, Raghav Jha and colleagues presents a quantum computational framework [arXiv:2410.14580] for SU(2) lattice gauge theory, leveraging continuous variables instead of discrete qubits to represent the infinite-dimensional Hilbert space of the gauge fields. The authors demonstrate how the system dynamics, ground states, and energy gaps can be computed using the continuous-variable approach to quantum computing. The results indicate that it is feasible to study non-Abelian gauge theories with continuous variables, providing new avenues for understanding the real-time dynamics of quantum field theories.

**Constraints on the U(1)B-L model from global QCD analysis**

The JAM Collaboration (Beyond the Standard Model Working Group), which includes physicists from the Theory Center and the University of Adelaide, has performed the first global QCD analysis [arXiv:2410.01205] of electron-nucleon deep-inelastic scattering and related high-energy data in the context of the B-L extension of the Standard Model. This BSM extension involves additional right-handed neutrinos and an extra U(1)B?L gauge boson, denoted by $Z'$. Contrary to the previously analyzed case of the Standard Model extended by the inclusion of a dark photon, no improvement was found in the $\chi^2$ relative to the baseline result. The finding allows the placement of exclusion limits on the coupling constant of the $Z'$ boson with mass in the range $M_{Z'} = 2$ GeV to 160 GeV.

**Point cloud-based diffusion models for the Electron-Ion Collider (EIC)**

At high-energy collider experiments, generative models can be used for a wide range of tasks, including fast detector simulations, unfolding, searches of physics beyond the Standard Model, and inference tasks. Drs. Nobuo Sato, Felix Ringer and collaborators have developed a model [arXiv:2410.22421] trained to generate entire collider events, including all particle species with complete kinematic information, such as those at the future Electron-Ion Collider. To deal with sparsity of the data, the authors use point clouds and a novel architecture combining edge creation with transformer modules (Point Edge Transformers), and adapt the foundation model OmniLearn to generate full collider events. This approach may indicate a transition toward adapting and fine-tuning foundation models for downstream tasks instead of training new models from scratch.