From Quarks and Gluons to the Internal Dynamics of Hadrons

Wednesday, May 15, 2024 - Friday, May 17, 2024

Center for Frontiers in Nuclear Science, Stony Brook University

Scientific Program

QCD is nowadays established as the theory of strong interactions. However, the Lagrangian of the theory doesn’t reveal any hints of hadronic degrees of freedom and merely allows us to deduce a set of rules for Green or correlation functions of quarks and gluons, that is the interaction between the fermions and gauge fields and the gauge fields themselves. On the other hand, what we measure are properties of hadrons, so we need to understand how the elementary fields produce them. In particular, the current quark’s mass only amounts to 2-3% of the proton mass, so the question arises: what mechanism produces the hadron’s masses, spin and angular momentum distribution and how is it related to the confinement of quarks and gluons? Perturbative approaches alone do not answer this question.

In recent years, a great deal of effort has been dedicated to understanding the nature of bound states in QCD, not merely their (excited) mass spectrum but also their charge and momentum distributions, their three-dimensional tomography and mass origin. This has been made possible with continuous effort and improvement of nonperturbative computational methods, chiefly amongst them are lattice QCD and functional approaches to QCD.

It turns out that the key to the above question is chiral symmetry and the pattern of its breaking, namely, the near preservation of chiral symmetry is responsible for the small pion mass, while other mesons and baryons acquire mass due to dynamical breaking of chiral symmetry or the trace anomaly of the energy momentum tensor in QCD. Moreover, chiral anomalies at the quantum level can also contribute to mass and their proper treatment imply nonperturbative calculations.

In the light of the experimental program at the EIC, a synergetic effort of practitioners in QCD is necessary to address open questions that are codified in one and higher dimensional momentum distributions, form factors, masses and other observables which are amongst the prime interests of the EIC community. This workshop serves to improve communication between the diverse communities of nonperturbative and perturbative QCD.