Novel method could explore gluon saturation at the future electron-ion collider

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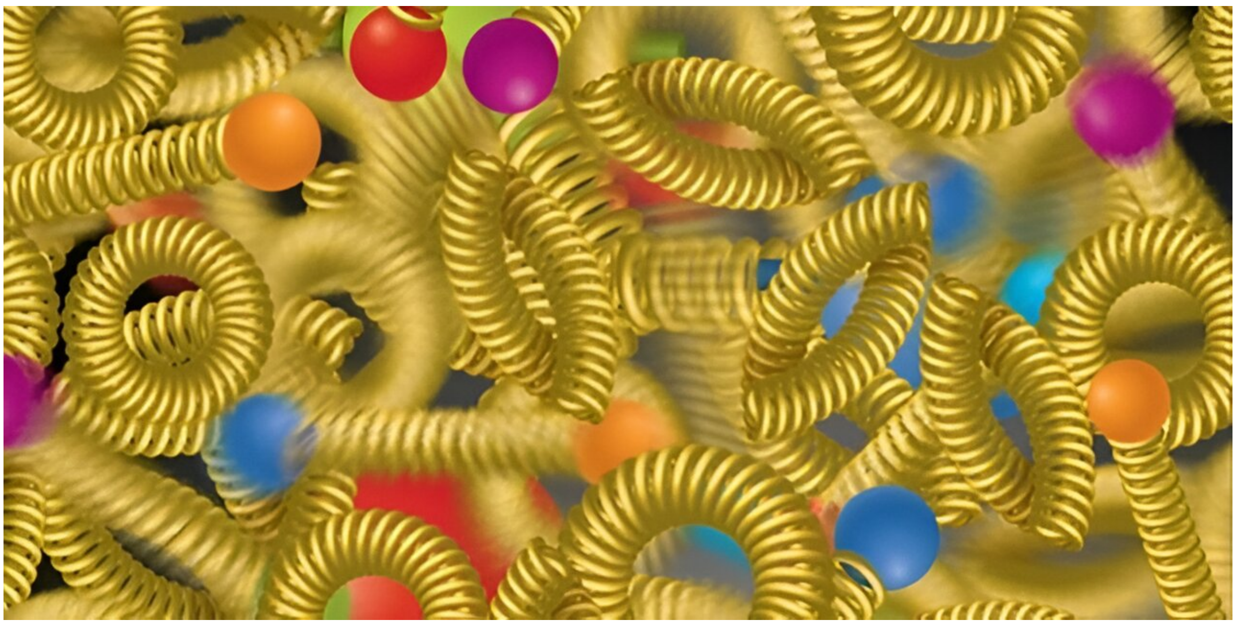

Exploring the gluon saturation in a large nucleus is one of the goals of the future Electron-Ion Collider. Researchers proposed a nucleon energy-energy correlation approach that provides a unique probe of the onset of gluon saturation. Credit: Brookhaven National Laboratory

The U.S. nuclear physics community is preparing to build the electron–ion collider (EIC), a flagship facility for probing the properties of matter and the strong nuclear force that holds matter together. The EIC will allow scientists to study how nucleons (protons and neutrons) arise from the complex interactions of quarks and gluons.

A project led by researchers at Lawrence Berkeley National Laboratory demonstrated an important probe to study gluon saturation at the future EIC. Gluon saturation is a phenomenon at the highest energies inside nuclei, when the production of gluons and their recombination balance out, resulting in a gluon density that no longer depends on the collision energy.

The project showed that the nucleon energy–energy correlation (NEEC) provides a distinguishing prediction from the theory that encodes the gluon saturation at high density. Thus, the NEEC measurements will offer a great opportunity to pin down the onset of the gluon saturation phenomenon in electron–nucleus collisions at the EIC.

The project resulted in two studies, one published in *Physical Review Letters* and the other in *Physical Review D*.

The NEEC probe has an advantage over other standard high-energy processes because it is fully inclusive. This makes the observable both theoretically and experimentally clean.

Researchers have also shown that the linearly polarized gluons confined inside the unpolarized nucleon can be analyzed through additional correlation of energy. The interference of gluons spinning in opposite direction translates into an asymmetry of count rates observed in the detector. This provides an exquisite signature of the linearly polarized gluons and a glimpse of the associated nucleon tomography.

This will lead to a comprehensive approach to study the universal behavior of gluon saturation. It will also complement the study of other high-energy processes at the future EIC.

More information: Hao-Yu Liu et al, Nucleon Energy Correlators for the Color Glass Condensate, *Physical Review Letters* (2023). DOI: 10.1103/PhysRevLett.130.181901

Xiao Lin Li et al, Illuminating nucleon-gluon interference via calorimetric asymmetry, *Physical Review D* (2023). DOI: 10.1103/PhysRevD.108.L091502

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