WG5: "QCD in Nuclei and associated Nuclear Modifications and Dynamics" Summary Discussion

Science at the Luminosity Frontier: Jefferson Lab at 22 GeV Workshop

INFN, Laboratori Nazionali di Frascati

Dec. 13th, 2024

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Addressed/Open Questions

- There is a gap between the traditional nuclear physics and QCD pictures, and the manifestation of such a gap in the valence quark region is the EMC effect
  - In this respect, many fundamental questions can be addressed
    - Are the quarks and gluons confined to nucleon-like objects?
    - Does this depend on, e.g., the momentum filter x_B?
    - What are the quark and gluon mass radii for ^{4}He and how?
    - does this contrast with the nucleon?
    - What are the pressure and shear forces in ^{4}He?
  - Does exploring these questions could be done by imaging light nuclei and comparing quarks and gluons for slices in x_B, k^2_T, and b^2_T?
  - Special emphasize to lightest nuclei up to Lithium-7
  - Exploring polarization properties, such as tensor polarized deuteron targets
  - Could go beyond traditional DIS structure function studies by addressing:
    - Spin and Gluon EMC effects, Flavor Dependence Nuclear PDFs, and TMDs
  - Measuring the charge and matter radius of nucleons in nuclear medium lead to probing modifications of quark and gluonic degrees of freedom

See I. Cloet's Talk

Addressed/Open Questions

- The most important issue is self consistent description of nuclei as a baseline theory for studies of medium modification effects
  - This includes the development of theoretical framework that addresses relativistic nature of bound system like nuclei
    - Macroscopic locality, Poincare Covariance, Satisfaction of baryonic and light-front sum rules
  - Only after this, a realistic extend of medium modifications can be assessed
    - Emphasize is on lightest nuclei
  - Quantities that can be calculated and used for medium modification studies
    - Unpolarized DIS structure functions; g_1 and g_2 distributions for ^{3}He to extract the neutron g_1
  - Extending the approach for nuclear TMDs and GPDs

See M. Rinaldi's Talk

Addressed/Open Questions

- Are there 3N Short Range Correlations and how to discover them?
  - New layer of scaling in inclusive cross section ratios

    - Why it wasn't observed before and can it be observed now?

    - Measure it @ sufficiently large Q^2 and address challenges related to that
  - Checking the possible quadratic relation between 2N and 3N SRCs
  - First possible measurements already at 12 GeV
  - Limitation of current detector systems for JLab 22 GeV (JLab22)

See N. Fomin's Talk

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- Tensor Deuteron Capability at Jefferson Lab from 12 to 22 GeV
  - This opens up completely new venues in probing strong force dynamics
    - Already limited measurements from HERMES, which showed surprising results
    - Measuring new quantity Anode that isolates the S state in the deuteron and allows to probe the nuclear core in $^3S_1$ channel
    - Transfer Momentum Distribution studies with SIDIS
  - Exploring SOLID + new recoil detector capabilities

See N. Santiesteban's Talk

Addressed/Open Questions

- Probe the nuclear core dynamics with measurements of super-fast quarks in nuclei @ JLab22;
  - Dominated by DIS, suppression of resonance, and QE contributions
  - The only option to reach necessary kinematics with sufficient precision
  - Higher Q^2 coverage leads to cleaner data and more interpretations
  - Constrain theoretical models by extending ξ to the region exhibiting rapid variations
  - Examine A and Q^2 dependence

See J. Arrington's talk

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- Which role the JLab22 upgrade would play in resolving the Color Transparency controversy between meson and baryon sectors?
  - Extend mesons (ρ^0, π^+) and baryon (*proton*) measurements to higher Q^2
  - Access other kinematics with sensitive FSIs in proton recoil polarization transfer
  - Explore other meson channels such as J/ψ in electro- and photo-production as confirmation of CT in the mesonic sector
  - Explore high-precision nuclear transparency measurements
  - Possibility to investigate CT for baryonic "neutral" channel!

See H. Schmilla-Vance's talk

Addressed/Open Questions

- How would the JLab22 upgrade help improve our understanding of 1) SIDIS production in nuclei, 2) dynamics leading to color confinement, 3) in-medium stimulated effects on fragmentation functions, and 4) time-distance scales of color-neutralization and hadron formation stages?
  - Broader kinematical coverage
  - Multi-fold extraction of experimental observables
  - Access rare meson (*D-meson*) and baryon (Ξ) channels, as well as explore diquark correlations in nucleon structure
  - Constrain theoretical models with various predictions of hadronization time-distance scales

See T. Mineeva's talk

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- How can the spectator tagging @ JLab22 access medium modifications and nuclear effects on quarks and gluons distributions?
  - Broader (x_B, Q^2) and finner (x_B, $-t$) kinematical coverage
  - Extract experimental observables, BSA → CFF & GPDs, for a broader kinematical coverage compared to the forthcoming CLAS12 ALERT studies

See M. Ouillon's talk

Addressed/Open Questions

- What is the impact of the JLab22 upgrade on accessing the anti-shadowing region and related medium modifications extended to the EMC region?
  - Study SIDIS with multi-hadron production and light-to-heavy nuclei
  - Access broader phase space and various fragmentation regions
  - Study of different meson (pions, kaons, etc.) and baryon (proton and Lambda, etc.) production will lead to flavor-tagging
  - 3-D mapping of nPDF → nGPDs, nFFs & nTMDs
  - The JLab22 high precision and luminosity will allow exploring the anti-shadowing region in which the nuclear structure function effects are the least studied experimentally

See Z. Ye' and N. Kalantarians's talks