## Light-Cone 2024: Hadron Physics in the EIC era



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## Progress on generalized parton distributions and gravitational form factors

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Masses and spins of hadrons are fundamental quantities in physics; however, their origins are not understood yet and their investigations are major purposes of building electron-ion colliders in 2030's. Both of them can be investigated by generalized parton distributions (GPDs). The *t*-channel or spacelike (*s*-channel or timelike) GPDs are studied by deeply virtual Compton scattering (two-photon processes) at charged-lepton accelerator facilities ( $e^+e^-$  collider facilities) such as the JLab, CERN-AMBER, and EICs (KEKB). Here, the s-channel GPDs are generally called generalized distribution amplitudes (GDAs) and they could be also called timelike GPDs because they contain timelike form factors. I discuss experimental prospects mainly at the  $e^+e^-$  collider KEKB, the hadron-accelerator facility J-PARC, and the Long-Baseline Neutrino Facility (LBNF) at Fermilab. It is possible to extract the s-channel GPDs and gravitational form factors of hadrons by the two-photon processes  $\gamma^* + \gamma \rightarrow h + h$ , where h is a hadron. Actually, there was the first report on the determination of the gravitational form factors and radii (mass and mechanical radii were 0.32-0.39 fm and 0.82-0.88 fm for  $\pi^0$ ) from actual experimental measurements in Ref.[1]. At J-PARC, the GPDs will be investigated by the exclusive Drell-Yan process  $\pi^- p \to \mu^+ \mu^- B$  [2], where the baryon B could be a nucleon or  $\Delta$ . In future, other processes could be investigated for the GPDs. For example, the  $2 \rightarrow 3$  reaction processes  $NN \rightarrow N\pi B$  could be used for probing the GPDs in the ERBL (Efremov-Radyushkin-Brodsky-Lepage) region. In addition, the neutrino facility Fermilab-LBNF, possibly also the nuSTORM at CERN, can be used for the GPD measurement by the single-pion production processes  $\nu + N \rightarrow \ell^- + N' + \pi$  and  $\bar{\nu} + N \rightarrow \ell^+ + N' + \pi$  [3].

## References

[1] S. Kumano, Qin-Tao Song, and O. V. Teryaev, Phys. Rev. D 97, 014020 (2018).

[2] S. Kumano, M. Strikman, and K. Sudoh, Phys. Rev. D 80, 074003 (2009), T. Sawada et al., Phys. Rev. D 93, 114034 (2016); J-K. Ahn et al., Letter of Intent for J-PARC, LoI\_2019-07; Wen-Chen Chang et al., J-PARC proposal under preparation.

[3] X. Chen, S. Kumano, R. Kunitomo, S. Wu, and Y.-P. Xie, arXiv:2401.11440, European Physical Journal A, in press.

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