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Probing the Pion Structure Beyond the Valence Sector in Light-Front Dynamics

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In this talk, we present an ongoing study of the internal structure of the pion using light-front dynamics, going beyond the leading Fock state approximation. We construct light-front wave functions (LFWFs) for the pion that include both quark–antiquark and quark–antiquark–gluon components. This allows us to capture more of the non-perturbative dynamics of the pion and go beyond simple valence-level descriptions. Utilizing these LFWFs, we compute a broad set of parton distributions such as parton distribution functions (PDFs), Form factors, Generalized parton distributions (GPDs) and Gravitational form factors. These observables provide detailed information about the momentum, spatial, and mechanical structure of the pion, revealing how partons are distributed and correlated inside the hadron. These studies are carried out within different light-front based models and help us understand how the results evolve when contributions beyond the valence sector are included. Our results contribute to the broader effort to explore the multidimensional structure of the pion and offers theoretical input for current and upcoming experimental programs at Jefferson Lab, COMPASS, and the Electron-Ion Collider.

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