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Pion to photon transition form factor: Beyond valence quarks

We investigate the singly virtual transition form factor (TFF) for the $\pi 0 \longrightarrow \gamma^{*}\gamma$ process in the space-like region using the hard-scattering formalism within the Basis Light-Front Quantization (BLFQ) framework. This form factor is expressed in terms of the perturbatively calculable hard-scattering amplitudes (HSAs) and the light-front wave functions (LFWFs) of the pion. We obtain the pion LFWFs by diagonalizing the light-front QCD Hamiltonian, which is determined for its constituent quark-antiquark and quark-antiquark-gluon Fock sectors with a three-dimensional confinement. We employ the HSAs up to next-to-leading order (NLO) in the quark-antiquark Fock sector and leading order (LO) in the quark-antiquark-gluon Fock sector. The NLO correction to the TFF in the quark-antiquark Fock sector is of the same order as the LO contribution to the TFF in the quark-antiquark-gluon Fock sector. We find that while the quark-antiquark-gluon Fock sector has minimal effect in the large momentum transfer (Q^2) region, it has a noteworthy impact in the low-Q^2 region. Our results show that, after accounting for both Fock sectors, the TFF within the BLFQ framework aligns well with existing experimental data, particularly in the low Q^2 region.

Primary authors: Prof. MONDAL, Chandan (中国科学院近代物理所); Prof. LAN, Jiangshan (中国科学院近代物理所); WU, Xiaoyi (中国科学院近代物理所)

Co-authors: Prof. VARY, James. P (爱荷华州立大学（美国）); Prof. ZHAO, Xingbo (中国科学院近代物理所); Dr ZHU, Zhimin (中国科学院近代物理所); Dr LIN, Ziyang (中国科学院近代物理所)

Presenter: WU, Xiaoyi (中国科学院近代物理所)