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The Frame-Independent Spatial Coordinate $\tilde{z}$: Implications for Light-Front Wave Functions, Deep Inelastic Scattering, Light-Front Holography, and Lattice QCD Calculations[1] GERALD A. MILLER, University of Washington, STANLEY J. BRODSKY, SLAC National Accelerator Laboratory, Stanford University — A general procedure for obtaining frame-independent, three-dimensional light-front coordinate-space wave functions is introduced. The third spatial coordinate, $\tilde{z}$, is the conjugate to the light-front momentum coordinate $x = \frac{k^+}{P^+}$ which appears in parton distributions. These light-front wave functions are used to derive a general expression for the quark distribution function of hadrons as an integral over the spatial separation $s = \tilde{z} - \tilde{z'}$, the frame-independent longitudinal distance (the Ioffe time) between virtual-photon absorption and emission in the forward virtual photon-hadron Compton scattering amplitude. The integrand, $g(s, x)$ of the quark distribution contains a factor of $\cos sx$ which remains significant for very large values of s at small x, thus demonstrating that the spatial extent of a proton in the longitudinal direction can be very large – a key feature of the Ioffe time. Specific examples using models derived from light-front holographic QCD exhibit a large extent in $\tilde{z}$.

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