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Going to the light-front with contour deformations

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Hadrons are strongly interacting particles composed of quarks and gluons and described by Quantum Chromodynamics (QCD). Their internal structure can be described in terms of structure functions that encode, for example, the momentum and spin distributions of their constituents. Parton distribution functions (PDFs), for example, describe the quark and gluon momentum distributions inside a hadron. These distribution functions are, however, not easy to calculate, because they are defined on the light front, whereas most hadron calculations are performed in a Euclidean metric and yield, for instance, the hadron's Bethe-Salpeter wave functions. The main problem is then to project these Bethe-Salpeter wave functions onto the light front.

We present a new method to compute the light-front wave functions using contour deformations, which we illustrate for a simple system of two interacting scalar particles of equal mass. After solving the two-body Bethe-Salpeter equation, the projection onto the light front is done through a combination of contour deformations and analytic continuation methods. The resulting light-front wave functions and distribution amplitudes are in agreement with the Nakanishi method frequently used in the literature. We show that the contour deformation method can also be used for particles of unequal masses, as well as particles with complex conjugate propagators poles, to make contact with QCD. Finally, we explore ways of extending this method to the calculation of more general parton distributions, such as transverse momentum distributions (TMDs) and generalized parton distributions (GPDs).

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