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Efficient computation of Hankel transforms based on Levin's method

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In the most commonly adopted approach to transverse momentum-dependent (TMD) factorization, the TMD parton distributions are expressed in position space, which is Fourier-conjugate to the transverse momenta. The transverse momentum-dependent observables are obtained through a two-dimensional Fourier transform, which can be reduced to a one-dimensional Hankel transform. Computation of this quantity is numerically challenging due to the presence of highly oscillatory integrals, which hinder accurate extraction of parton distributions from experiments.

In our work, we have developed an algorithm for the efficient computation of Hankel transforms based on Levin's method [1]. This method combines speed and precision, simultaneously utilizing a fixed grid in the position space in a wide range of transverse momenta. Our approach is integrated into ChiliPDF library [2]. In this talk, I will describe Levin's method, provide an outline of the algorithm, and present a comparison of its precision against that of adaptive methods [3].

[1] D. Levin, Fast integration of rapidly oscillatory functions, J. of Computational and Applied Mathematics 67 (1996) 95-101.
[2] M. Diehl, R. Nagar, F. Tackmann, ChiliPDF: Chebyshev interpolation for parton distributions, Eur.Phys.J.C 82 (2022) 3, 257.
[3] Z.B. Kang, A. Prokudin, N. Sato, J. Terry, Efficient Fourier Transforms for Transverse Momentum Dependent Distributions, Comput. Phys. Commun. 258, 107611 (2021).

Summary

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