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Parton Fragmentation Functions in Electron-positron Annihilation extracted via a Physics-Informed Neural Network

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In high-energy physics, accurately predicting cross sections of reaction processes relies heavily on the parton fragmentation functions (FFs). Conventional methods often require parameterized forms and additional calculations to ensure the FFs conform to the Dokshitzer-Gribov-Lipatov-Altarelli-Parisi (DGLAP) evolution equations, which can be cumbersome and may not fully capture the complexity of FFs across varying energy scales. Here, we introduce a novel approach to determining parton fragmentation functions using a Physics Informed Neural Network (PINN). Unlike traditional methods, our approach does not require prior parameterized forms and directly integrates the DGLAP evolution equations into the neural network architecture, allowing the FFs to automatically satisfy these equations without additional calculations. We present new sets of parton FFs obtained for hadrons in electron-positron annihilation processes at next-to-leading order (NLO) in pQCD using this innovative technique. To validate our approach, we calculate proton-(anti)proton hadron spectra using the extracted FFs and demonstrate that our theoretical predictions align well with experimental data across various energy scales ($\sqrt{s}$ = 130, 200, 500, 630, 900, 1800, 2760, 5020, 5440, 7000 GeV). Our findings indicate that the PINN method not only simplifies the extraction process but also enhances the universal applicability of FFs across different energy scales. By eliminating the need for parameterized forms and additional DGLAP evolution, our approach represents a significant step forward in the field, paving the way for more robust and versatile predictions in high-energy physics, including the potential exploration of new research avenues in heavy ion collisions.

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