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From Quarks to Tetraquarks: Heavy-Flavor Fragmentation and Exotic Matter

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We present the first comprehensive study of fragmentation into fully heavy tetraquarks, based on the newly released TQ4Q1.1 set of collinear, variable-flavor-number-scheme fragmentation functions. Covering scalar (0^{++}), axial-vector (1^{+-}), and tensor (2^{++}) configurations, our analysis provides a pioneering framework to explore exotic-matter production with precision QCD tools. For the first time, we quantify and propagate key sources of uncertainty, from color-composite long-distance matrix elements to missing higher-order contributions in both the hard and fragmentation sectors. This work offers a robust reference for ongoing analyses at the LHC and for future explorations at its High-Luminosity upgrade and next-generation accelerators. As an outlook, we discuss the potential of a multimodal fragmentation strategy, aimed at combining different production mechanisms, including diquark clusters and molecular components, to further refine predictions and improve the connection between QCD dynamics and exotic matter phenomenology.

Abstract

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