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From A-hypergeometric systems to canonical differential equations for Feynman integrals using D-modules

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Feynman integrals are fundamental building blocks of scattering amplitudes and correlation functions, and their efficient evaluation is essential for high-precision predictions at the Large Hadron Collider and for applications in gravitational wave physics and cosmology. A central challenge is the construction of manageable systems of differential equations, whose size can grow substantially with the complexity of the integral family. In this talk, we present a D-module framework that provides a systematically reduced description of these systems. By associating Feynman integrals in their Schwinger-parametric representation with Gel'fand–Kapranov–Zelevinsky (GKZ) hypergeometric systems, we construct Pfaffian systems whose dimension is controlled by the holonomic rank of the underlying D-module. For a range of one- and two-loop examples, we find that this dimension is no larger than the number of master integrals obtained through integration-by-parts (IBP) reduction, and is strictly smaller in several cases. The resulting systems can be transformed into canonical ϵ-form, providing a direct route to the analytic structure and differential equations governing the integrals. These results demonstrate that D-module and GKZ methods can yield reduced differential systems for Feynman integrals and offer a complementary approach to the standard IBP framework.

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