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IBP Reduction using Gröbner bases

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Integral reduction based on integration-by-parts (IBP) identities are an indispensable tool for accomplishing higher-order calculations in perturbative quantum field theory. We approach this task from the point-of-view of algebraic geometry by solving the system of IBP equations symbolically. We formulate the problem as a non-commutative rational double-shift algebra Y and a left ideal that the IBP equations generate therein. For simple examples we compute the Gröbner basis of the left ideal in Y. For more complicated problems we compute so-called normal-form IBPs from a linear algebra ansatz, whose solution makes use of techniques from finite fields and rational reconstruction. Both, the Gröbner basis and the normal-form IBPs, allow for a fast and targeted reduction of integrals. We also report on open issues and ongoing developments, among which the extension of the algebra by including the dimensional shift operator. The presentation is based on arXiv2207.09275, arXiv2210.05347, and work in progress.

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