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Automatic computation of Feynman integrals containing linear propagators via auxiliary mass flow

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We proposed a recipe to systematically calculate Feynman integrals containing linear propagators using the auxiliary mass flow method. The key of the recipe is to introduce a quadratic term for each linear propagator and then using differential equations to get rid of their effects. As an application, we calculated all master integrals of vacuum integrals containing a gauge link up to four loops, and we checked the results by nontrivial dimensional recurrence relations.

Summary

In summary, we develop a recipe to calculate linear integrals using the AMF method~\cite{Liu:2017jxz,Liu:2020kpc,Liu:2021wks}. For any given linear integral, our recipe is to introduce an auxiliary quadratic term for each linear propagator, and the obtained auxiliary quadratic integral can be calculated systematically using the AMF method. Taking the result of the auxiliary quadratic integral calculated at fixed auxiliary quadratic terms as the boundary condition and using differential equations to push the auxiliary quadratic terms to zero, effects of auxiliary quadratic terms will die out eventually, and we get the result of the target linear integral. This recipe of calculating linear integrals is very systematic and has been implemented in the package~\texttt{AMFlow} \cite{AMFlow}.

As linear integrals show up frequently in region expansion and in effective field theories, our recipe will be useful in phenomenological studies. As the first application, we have calculated all MIs of vacuum integrals containing a gauge link up to four loops,
which are useful to study parton distribution functions. Our results have been checked by nontrivial dimensional recurrence relations.

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