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High Performance and Increased Precision Techniques for Feynman Loop Integrals

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For the investigation of physics beyond and within the Standard Model, the precise evaluation of higher order corrections in perturbative quantum field theory is required. We have been developing a computational method for Feynman loop integrals with a fully numerical approach. It is based on a numerical integration techniques and an extrapolation. In this presentation, we describe the status and new developments in our approaches for the numerical computation of Feynman loop integrals up to four loops.

Founded on underlying asymptotic error expansions, extrapolation and transformation methods allow for accurate automatic evaluation of Feynman loop integrals in the presence of integration difficulties such as boundary singularities. These techniques include linear and non-linear extrapolations, and double exponential and other transformations. Iterated one-dimensional integration with extrapolation has provided good accuracy for low-dimensional problems, such as for an ultra-violet 2-loop vertex diagram that gives rise to a 3-dimensional integral.

We are further focusing on improving the efficiency of these computations with respect to speed as well as precision. For accelerating the performance we have used the transparent and portable approach for multivariate integration offered by the parallel/distributed package ParInt, layered over MPI message passing for execution on a cluster, which implements a variety of methods and also comes with a quadruple (C long double) precision version. Alternatively, excellent speedups and precision have been obtained using dedicated hardware acceleration on double exponential/ trapezoidal rule sum approximations. Multivariate integration results will be included for 3- and 4-loop self-energy diagrams.

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