Multi-loop amplitudes for colliders

a Snowmass Letter of Interest

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Survey advances in perturbative methods for collider precision phenomenology

emphasis on computational demands

$\int \mathrm{d}\,\mathrm{PS}$ scattering amplitudes in terms of loop integrals

- Scattering amplitudes
- Loop integrals
- Subtraction techniques and phase space integration

Amplitudes

- Numerical methods for high multiplicity amplitudes (1-loop, beginning 2-loop)
- Unitarity for multi-loop
- Reconstruction of efficient analytical expressions
- Automatization NLO EW; off-shell $t\bar{t}X$ at NLO

Master loop integrals

- Reduction to master integrals ("IBP", finite field, finite basis, canonical basis)
- Evaluation of integrals (polylogs, elliptic; numerical: diff. eq.; sector decomposition)

Higher-order subtractions

- Fully local subtractions and slicing methods
- Each advantages and drawbacks (computationally, reusability, extensibility)

To summarize

Current needs mostly satisfied sufficiently with a few dozen PCs...

(no inherent limitation compared to manpower and efficient techniques and algorithms)

... but HL-LHC era computing times likely to change this

- Current algorithms (scaling, parallelizable, runtime (debugging)...)
- HPC setup? (memory, disk storage, licenses, ...)
- HPC readiness? (MPI, OpenMP, checkpointing, ...)

Snowmass: Time to survey towards need of more dedicated HPC support