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How to reduce O(a^2) effects in gradient flow observables?

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The gradient flow has become a very useful tool both for scale setting and for defining suitable finite volume schemes for the gauge coupling. However, surprisingly large cutoff effects have been observed in some cases. We here investigate these effects at leading order in perturbation theory and reproduce qualitative features that have previously been observed in the context of scale setting. We demonstrate that the leading O(a^2) effects can be completely eliminated through a combined improvement of the observables, the action and the gradient flow.
We then focus on finite volume couplings with SF boundary conditions
and analyze the size of remaining cutoff effects, both from the bulk and the boundaries. This leads us to the definition of our preferred set-up and preliminary simulation results in the pure SU(3) gauge theory corroborate our findings.

Primary authors: RAMOS, Alberto (NIC@DESY-Zeuthen); SINT, Stefan (Trinity College Dublin & NIC@DESY-Zeuthen)

Presenter: SINT, Stefan (Trinity College Dublin & NIC@DESY-Zeuthen)

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