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New polynomially exact integration rules on U(N) and SU(N)

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In lattice QFT, we are often presented with integrals over polynomials of coefficients of matrices in $U(N)$ or $SU(N)$ with respect to the Haar measure. In some physical situations, e.g., in presence of a chemical potential, these integrals are, however, numerically very difficult since they are highly oscillatory which manifests itself in form of the sign problem. In these cases, Monte Carlo methods often fail to be adequate, rendering such computations practically impossible.

In this talk, we will propose a new class of polynomially exact integration rules on $U(N)$ and $SU(N)$ which are derived from polynomially exact rules on spheres. We will examine these quadrature rules and their efficiency at the example of a $0+1$ dimensional QCD for a non-zero quark mass and chemical potential. In particular, we will demonstrate the failure of Monte Carlo methods in such applications but that we can obtain arbitrary precision results using the new polynomially exact integration rules.

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