Appendix A: $SU(3)$ projection

In this appendix we describe the two $SU(3)$ projection schemes used in this paper and show their equivalence in the weak coupling limit. Necessary properties of the projector mapping an arbitrary, complex 3×3 matrix on the $SU(3)$ subgroup are idempotence and gauge-covariance. These properties are not sufficient to specify a unique projector and hence several choices exist. For APE smearing we use the unit circle projection [46] which is based on polar decomposition, while for HYP smearing we seek iteratively the matrix $U_{\max} \in SU(3)$ which maximizes $\mathrm{Re}\,\mathrm{Tr}(U_{\max} V^\dagger)$ [47].

First we describe the unit circle projection [46]. For a complex 3×3 matrix V with $\det(V) \neq 0$, we calculate the matrix

$$W = V[V^\dagger V]^{-1/2}, \tag{A1}$$

which is unitary by construction and has a spectrum lying on the unit circle. The square root is obtained by Jacobi matrix diagonalization. From W we obtain a special unitary matrix by computing

$$\overline{V} = [(\det(W)]^{-1/3} W. \tag{A2}$$

This projection is idempotent since an element of $SU(3)$ is projected by Eqs. (A1) and (A2) back onto itself. The projection is also gauge covariant, as we now show. The matrices V and $V^\dagger$ transform as

$$V \to G_L V G_R^\dagger \qquad \text{and} \qquad V^\dagger \to G_R V^\dagger G_L^\dagger, \tag{A3}$$

and hence

$$V^\dagger V \to G_R V^\dagger V G_R^\dagger. \tag{A4}$$

Since $[V^\dagger V]^{-1/2}$ has the same transformation properties as $V^\dagger V$ one finds for the transformation of W

$$W \to G_L W G_R^\dagger, \tag{A5}$$

from which the gauge-covariance of $\overline{V}$ follows.