Locality of Overlap Fermions with fixed topology

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Locality of Overlap Fermions

• Outside of the Aoki phase, the eigenmodes of $H_w$ are localized. (conjecture)


$H_w$ ; hermitian Wilson Dirac operator

• Then Overlap Fermions are local.

$$D = 1 + \gamma_5 \frac{H_w}{\sqrt{H_w^2}}$$
Extra-Wilson Fermion/pseudo-Fermions
with twisted mass


• add extra-Wilson Fermions/pseudo-Fermions with twisted mass to the Overlap Fermion action.

\[ S = \sum \bar{\psi} D_{ov} \psi + \sum \bar{\chi} D_w (-m_0) \chi + \sum \bar{\phi} [D_w (-m_0) + i\mu \gamma_5 \tau_3] \phi \]

\( D_w \); Wilson Dirac Operator

• Effect of the additional term for partition function.

\[ \text{det} \left[ \frac{H_w^2}{H_w^2 + \mu^2} \right] \]

• addition of extra-Wilson Fermions corresponds to fixing the topology.
Change of the Aoki phase structure by fixing the topology

\[ \langle \pi_3 \rangle = 2\pi \rho(0) \]

\[ \rho(0) = \lim_{\lambda \to 0} \frac{1}{V} \int \mathcal{D}U e^{-S_G} \prod_n \left[ \frac{\lambda_n^2}{\lambda_n^2 + \mu^2} \right] \sum_n \delta(\lambda - \lambda_n) \]

\overset{\rightarrow}{\rightarrow} 0

effect of extra-Wilson Fermion

eigenmodes of \text{Hw}

localized
• The Aoki phase structure is changed by fixing the topology.

• If we add extra-Wilson Fermions/pseudo-Fermions to the action, the Overlap Fermion is local in strong-coupling region such as \( \beta = 5.28 \) (a~0.4fm)