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Δ_{mix} for overlap on a HISQ sea.

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Abstract: ...

Contents

1 Research

We have in mind something along the lines of [1] which looks at overlap on domain-wall. The "master formula" involves pseudoscalar meson masses determined using propagators calculated from both valence and sea Dirac operators. A similar approach is used in [2] for domain-wall on asqtad. The determination of $a^2\Delta_{\rm mix}$ extends the work of [3] to the fine asqtad ensemble. The prior work computed on only the coarse and uses yet another parametrization which appears well-justified based on that paper's discussion. For overlap on HISQ the pseudoscalar masses at LO are given as:

$$m^2_{vv'} = B_{\rm ov}(m_v + m_{v'}) \tag{1.1}$$

$$m^2_{ss'} = B_{\rm HISQ}(m_s + m_{s'}) + a^2\Delta_t \tag{1.2}$$

$$m^2_{vs} = B_{\rm ov} m_v + B_{\rm HISQ} m_s + a^2\Delta_{\rm mix} \tag{1.3}$$

Δ_t measures taste-breaking and in particular vanishes for the taste-5 GB pion. I am unclear on whether there is an additional $\Delta_{\rm sea}$ term arising in (1.2) and (1.3) when the valence sea-mass doesn't match the sea mass, but it looks like there is not such a term.. I need to understand this better. Some theory references: [4][5][6]

Ref. [3] has details of constructing the "Wilsonized" propagator from the staggered propagator, i. e. a 4-component object, and also many useful details regarding the fit-forms of the two-pt functions. I think is just the inverse of the Wilson $\to$ staggered transformation, and it is implemented in `inline_stag_to_wils.cc` in Chroma.

1.1 Overlap on HISQ propagators - Measurement Strategy

I am successfully parsing the overlap propagators, with results for pion correlators that agree with Nilmani for both single and double mass propagators. We need to discuss what all data is available and where (including what I may have already), and how much of that we want to run the measurements on..

1.2 HISQ propagators.

Right now we are looking at the $24^3 \times 64$ HISQ ensembles with dynamical charm [7]. We have unitary propagators for the following masses (cf Table IX p.16):

```
6.00(24^3X64) : 0.0102(m_l) 0.0509(m_s) 0.635(m_c)
6.30(32^3X96) : 0.0074 (m_l) 0.037(m_s) 0.440
6.72(48^3X144) : 0.0048 (m_l) 0.024(m_s) 0.286
```

On $24^3 \times 64$ there are 81 configurations.

I find that the "kaon" effective mass plots have an oscillatory behavior, as compared to the pions. I would like to understand this better. In practice I still fit the standard cosh form because I think the oscillating state has a much higher mass. Preliminary results for all combination of HISQ masses are in Fig. 1.

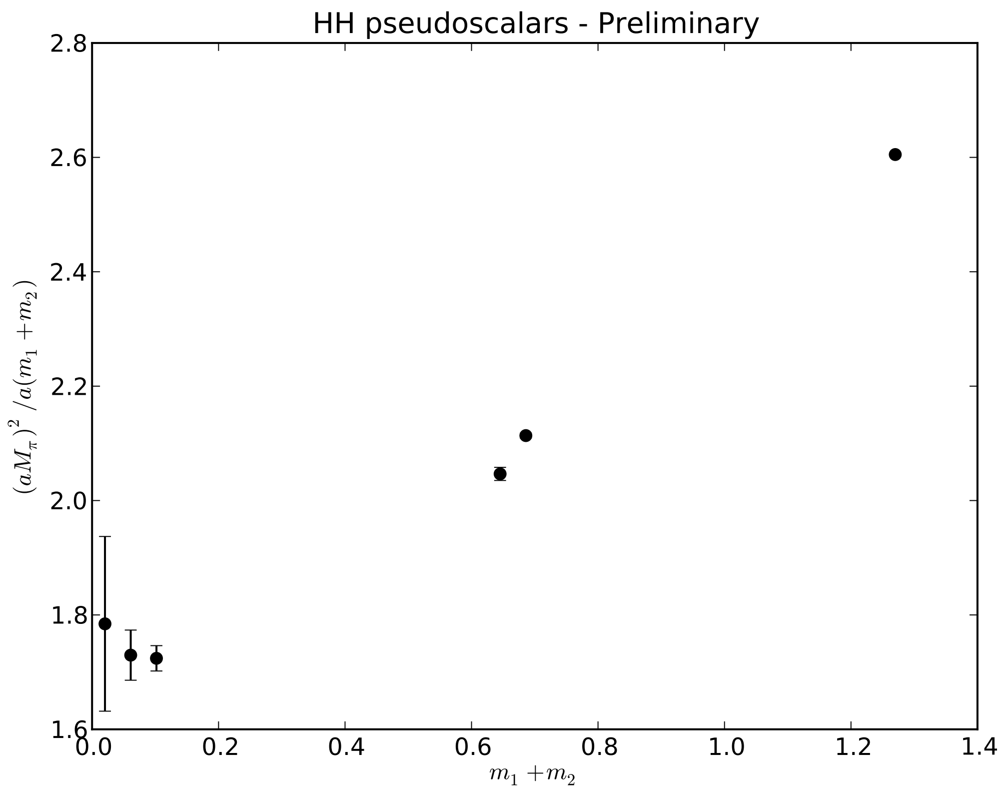

Figure 1: HISQ valence on HISQ sea. We see flat behavior in the pion-kaon mass range, whereas when including the charm mass clearly 1.2 breaks down.

HISQ propagators are constructed using a "corner wall" source. This source is 1 at all sites $\{(\mathbf{x}, t) \,|\, \mathbf{x}\%2 = \mathbf{0}$ and $t = t_0\}$.

1.3 Mixed action propagators.

The *Wilsonized* staggered propagator is given by the relation

$$D_{\psi_s}(x;y) = \Omega(x)\Omega^{\dagger}(y)D_{\chi}(x;y)\,, \tag{1.4}$$

where $\Omega(x) = \prod_{\mu}(\gamma_{\mu})^{x_{\mu}}$ is the Kawamoto-Smit transformation and $D_{\chi}(x;y)$ is the naive staggered propagator. All of the spin degrees of freedom are contained in the product of Ωs.

In order to combine the Wilsonized propagator with the overlap propagator, we need to ensure that both propagators share the same γ conventions. The overlap propagators are written (and read) using the Kentucky convention. The only remnant of gamma matrices in the staggered propagator is via the staggered phase conventions $\eta_{\mu}(x)$. These are equivalent to specifying precisely the Kawamoto-Smit transformation, but do *not* depend on the gamma convention used. Thus we need to ensure the correct ordering of the gammas in $\Omega(x)$, where the gamma matrix conventions are taken as Kentucky. There is an implementation of the conversion in MILC v7 `staggered2naive.c`. For now I am assuming that the correct transformation follows that, i.e. the HISQ phase conventions for the lattices I have follow that indicated here in the MILC code.

References

[1] M. Lujan, A. Alexandru, Y. Chen, T. Draper, W. Freeman, et al., *The Δ_{mix} parameter in the overlap on domain-wall mixed action*, *Phys.Rev.* **D86** (2012) 014501, [arXiv:1204.6256].

[2] C. Aubin, J. Laiho, and R. S. Van de Water, *Discretization effects and the scalar meson correlator in mixed-action lattice simulations*, *Phys.Rev.* **D77** (2008) 114501, [arXiv:0803.0129].

[3] K. Orginos and A. Walker-Loud, *Mixed meson masses with domain-wall valence and staggered sea fermions*, *Phys.Rev.* **D77** (2008) 094505, [arXiv:0705.0572].

[4] C. Aubin and C. Bernard, *Pion and kaon masses in staggered chiral perturbation theory*, *Phys.Rev.* **D68** (2003) 034014, [hep-lat/0304014].

[5] O. Bar, C. Bernard, G. Rupak, and N. Shoresh, *Chiral perturbation theory for staggered sea quarks and Ginsparg-Wilson valence quarks*, *Phys.Rev.* **D72** (2005) 054502, [hep-lat/0503009].

[6] J.-W. Chen, D. O'Connell, and A. Walker-Loud, *Two Meson Systems with Ginsparg-Wilson Valence Quarks*, *Phys.Rev.* **D75** (2007) 054501, [hep-lat/0611003].

[7] **MILC Collaboration** Collaboration, A. Bazavov et al., *Lattice QCD ensembles with four flavors of highly improved staggered quarks*, *Phys.Rev.* **D87** (2013), no. 5 054505, [arXiv:1212.4768].