WWU MÜNSTER · Graduiertenkolleg 2149 Research Training Group · NRW-FAIR Netzwerk · BERGISCHE UNIVERSITÄT WUPPERTAL · FOR 5269

Optimized Distillation Profiles for Heavy-Light Spectroscopy

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Distillation Profiles

Distillation operator:

$$S(t) = V(t)\,\mathbf{J(t)}\,V^\dagger(t)$$

$$J_{\substack{i,j\\ \alpha,\beta}}(t) = \delta_{ij}\,\delta_{\alpha\beta}\,\mathbf{g(\lambda_i(t))}$$

The perambulator:

$$\tau(t_1,t_2) = V^\dagger(t_1)\,D^{-1}\,V(t_2)$$

The elemental:

$$\Phi_{\substack{i,j\\ \alpha,\beta}}(t) = V_i^\dagger(t)\,\Gamma_{\alpha,\beta}(t)\,\mathbf{g^*(\lambda_i(t))}\,\mathbf{g(\lambda_j(t))}\,V_j(t)$$

The meson 2pt correlator:

$$-\langle \mathrm{tr}\left[\Phi_2(t)\,\tau_{q_a}(t,0)\,\bar{\Phi}_1(0)\,\tau_{q_b}(0,t)\right]\rangle_{\mathrm{gauge}}$$

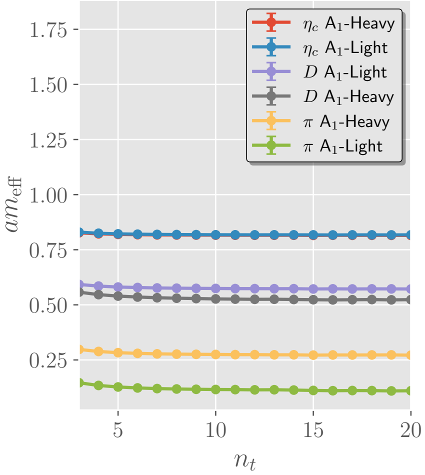
- Choose basis $g_n(\lambda) = \exp(-\frac{\lambda^2}{\sigma_n^2})$
- Optimize Φ with GEVP
- Get profile $f = \sum_n c_n g_n^* g_n$

[F. Knechtli, T. Korzec, M. Peardon, J. A. Urrea-Niño, Phys. Rev. D106 (2022)]

Ensembles

Name	N_f	a[fm]	$L^3 \times T$	N_v	m_π[GeV]
A11	3+1	0.054	$32^3 \times 96$	200	$\approx 1/\approx 0.4$
D5	2	0.0653	$24^3 \times 48$	200	0.439

- A1 at $SU(3)$ symmetric point
- We use A1_{light}
- Varying N_{cfg} used
- D5: periodic boundary conditions, $O(a)$ improved Wilson fermions [PoS(Lattice 2011)232]



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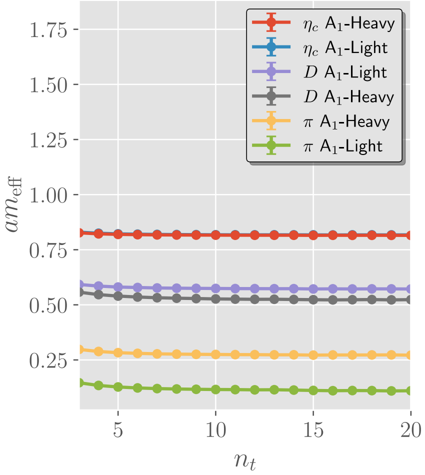
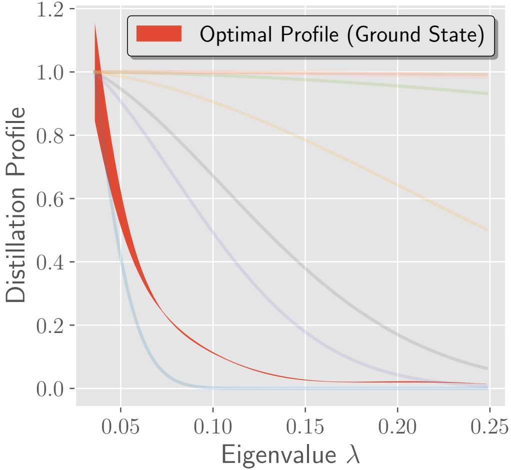
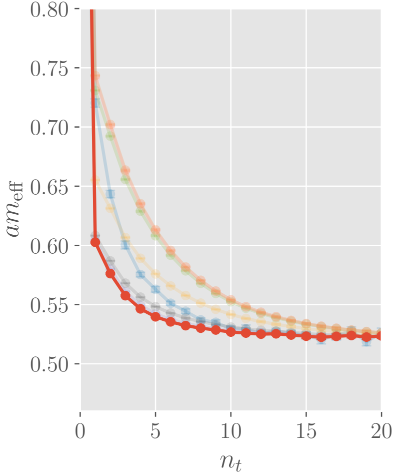


Motivation

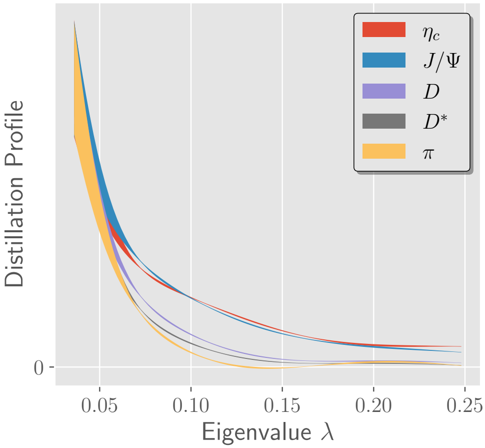
- Preparation for a future $D\bar{D}$ scattering analysis
  - Optimized profiles can be used for different traces/diagrams
- Distillation profiles improve charmonium excited state spectroscopy
  - Interest in D5 from [PoS(LATTICE2022)266]

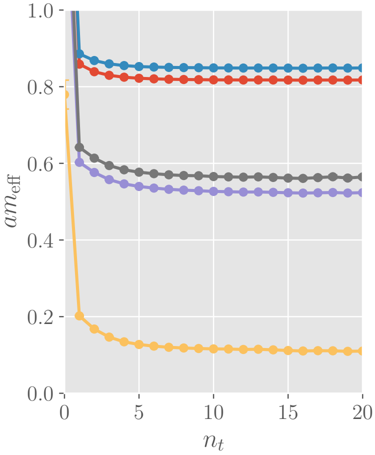
Demonstration of Heavy-Light Profiles





Comparing Profiles of Different Particles

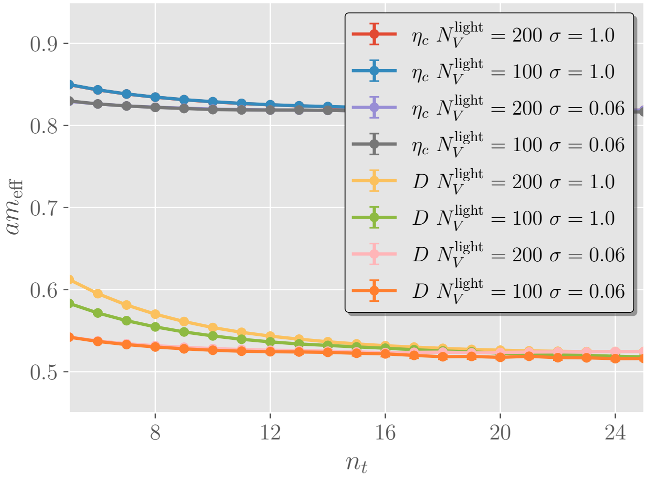




- Charmonium wider than D
- D wider than π
- **Wider** profile $\Longleftrightarrow$ more **localized** source

Restricting N_V^{Light}

- $4 \times N_v \times T$ inversions
- N_v^{Light} and N_v^{Charm} can differ $\implies$ rectangular elementals
- Wider Profiles are more affected
- Optimal D profiles are narrow



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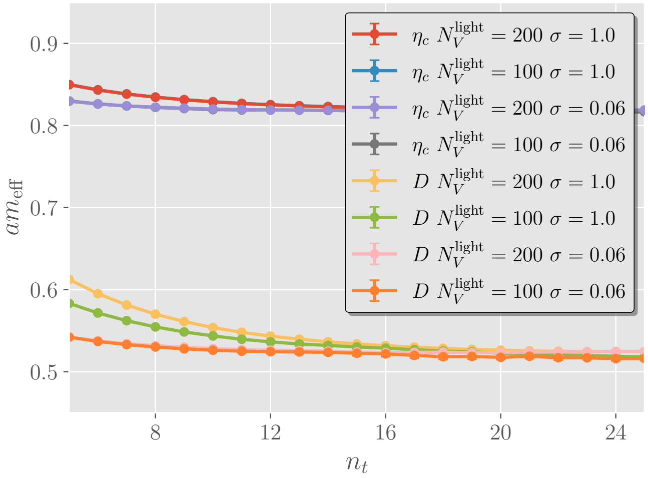


Profiles and Momenta

Elementals with lattice momentum:

$$\Phi_{i,j}(\vec{p}) = \sum_{\vec{x}} V_i^\dagger(\vec{x})\, e^{-i\vec{p}\cdot\vec{x}}\, g^*(\lambda_i)\, g(\lambda_j)\, \Gamma\, V_j(\vec{x})$$

The momentum part can be **precalculated**

$$\Phi_{i,j}(\vec{p}) = \Phi_{i,j}(\vec{0}) \sum_{\vec{x}} V_i^\dagger(\vec{x})\, e^{-i\vec{p}\cdot\vec{x}}\, V_j(\vec{x})$$

This is the **only additional cost**

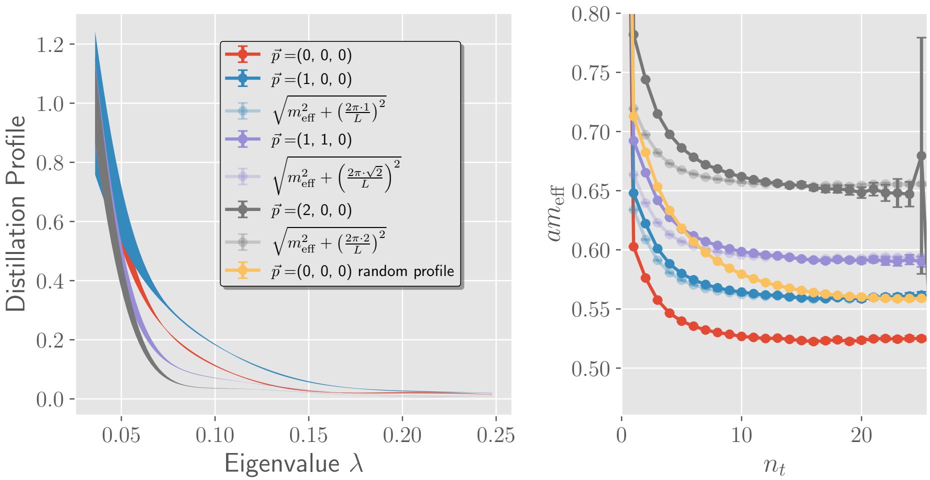
Alternative:

Partially twisted periodic boundary conditions

- Inversion with $\psi(x+L) = e^{i\theta}\psi(x)$ $\implies p = \frac{2\pi n+\theta}{L}$
- Allows **continuos momenta**
- Requires **new inversions**

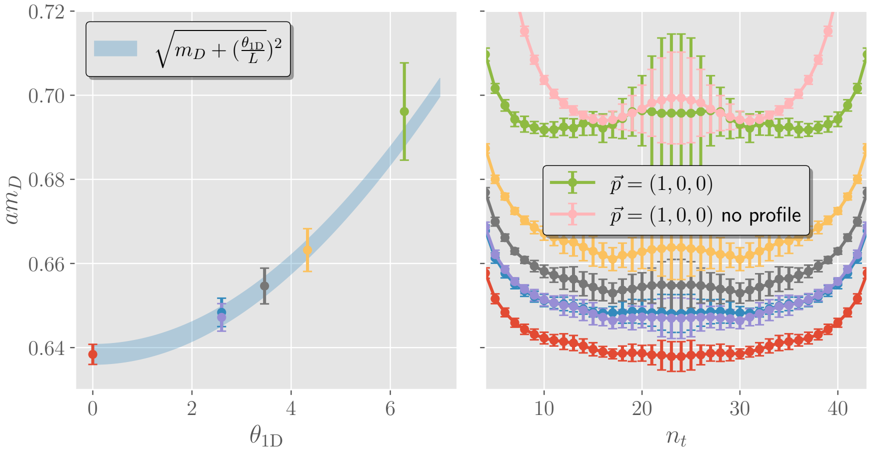
Profiles and Momenta

A1 $(N_f = 3 + 1)$



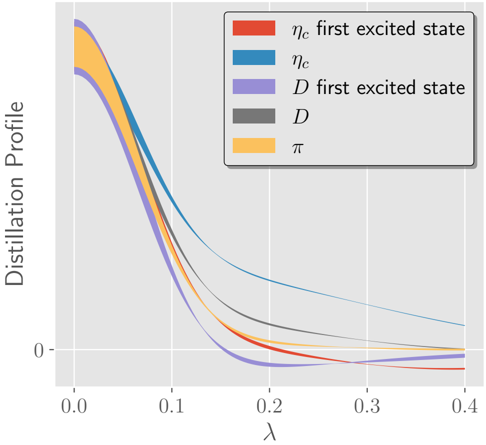
Profiles and Momenta

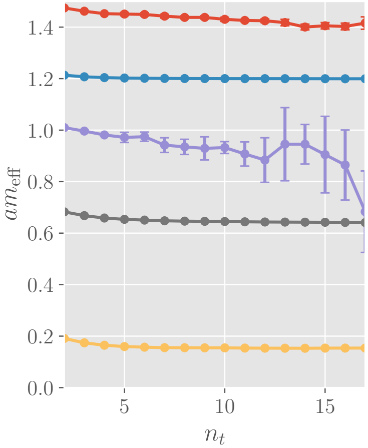
D5 ($N_f = 2$)



- Both methods fulfill **dispersion relation**
- Profiles are effective at higher momenta

Profiles on D5

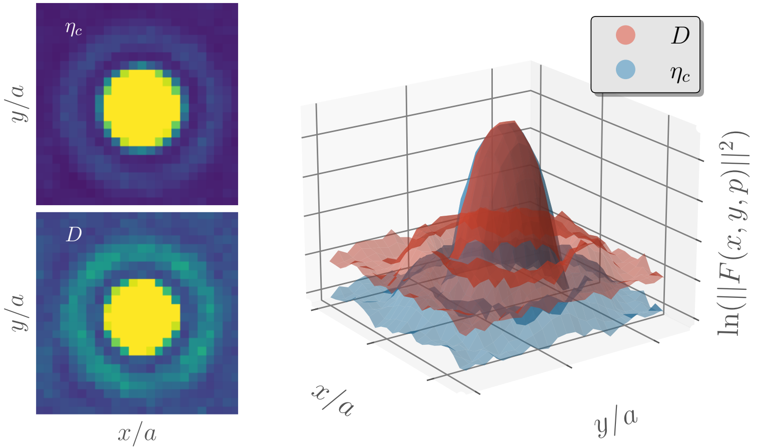




- Profiles resemble those on A1
- Different x-axis scaling
- Different form for excited states

Profiles on D5

- Reconstructed distillation operator **applied to point source**
- **Spatial slice** and average over n_t and configurations
- $\mathrm{tr}\left[\gamma_5\Gamma\right]$ and color average for **scalar value**
- D shows non-localized background



Summary

We have seen that distillation profiles work for:

- **heavy-light** systems
- different types of **momenta**

The optimized profiles are:

- **narrower for D** compared to charmonium
- consistent across ensembles

Thank you for your attention!