

Executed Command

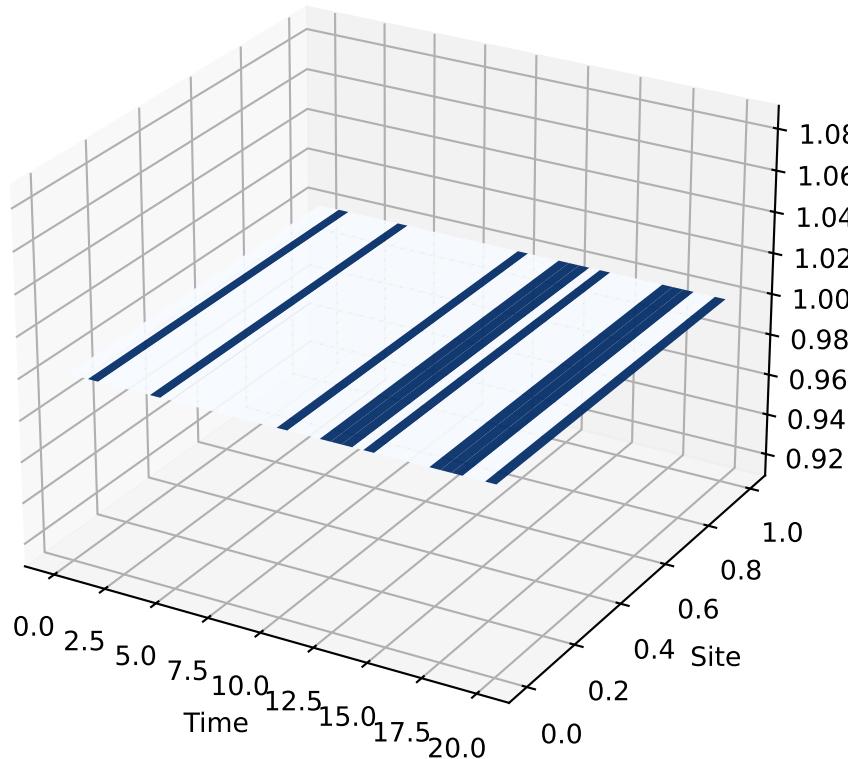
Reference: pipelines/PIPELINE_RUN_GUIDE.md

Script: pipelines/hardcoded_hubbard_pipeline.py

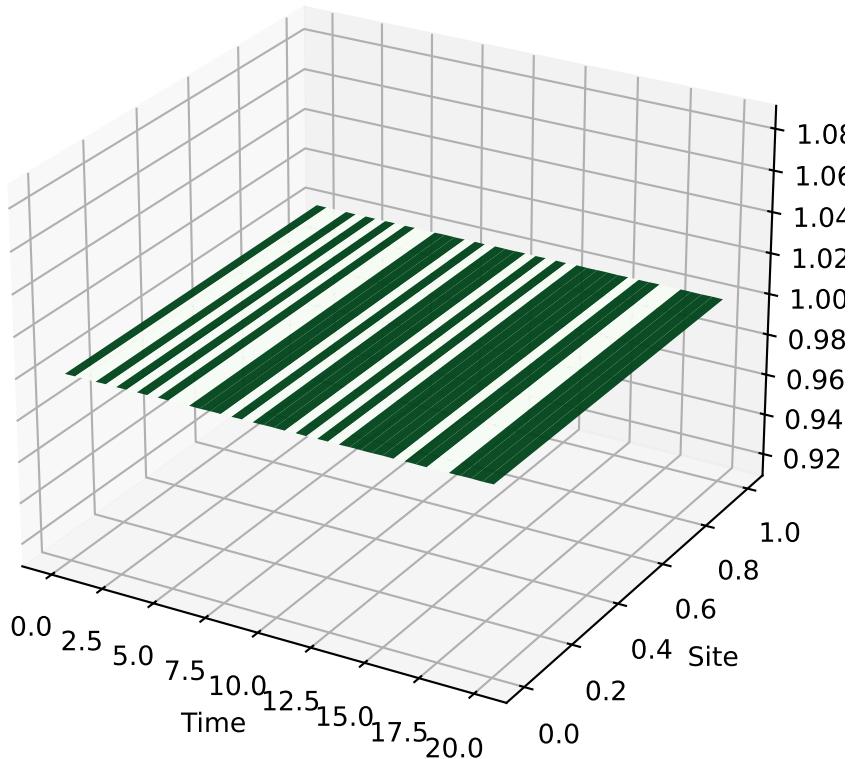
```
/opt/anaconda3/bin/python pipelines/hardcoded_hubbard_pipeline.py --L 2 --t 1.0 --u 4.0 --dv 0.0 --boundary
periodic --ordering blocked --t-final 20.0 --num-times 201 --suzuki-order 2 --trotter-steps 64 --term-order
sorted --vqe-reps 2 --vqe-restarts 1 --vqe-maxiter 120 --skip-qpe --initial-state-source vqe --fidelity-
subspace-energy-tol 1e-8 --output-json artifacts/json/H_L2_static_t1.0_U4.0_S64_heavy.json --output-pdf
artifacts/pdf/H_L2_static_t1.0_U4.0_S64_heavy.pdf
```

L=2 3D Densities (Total n)

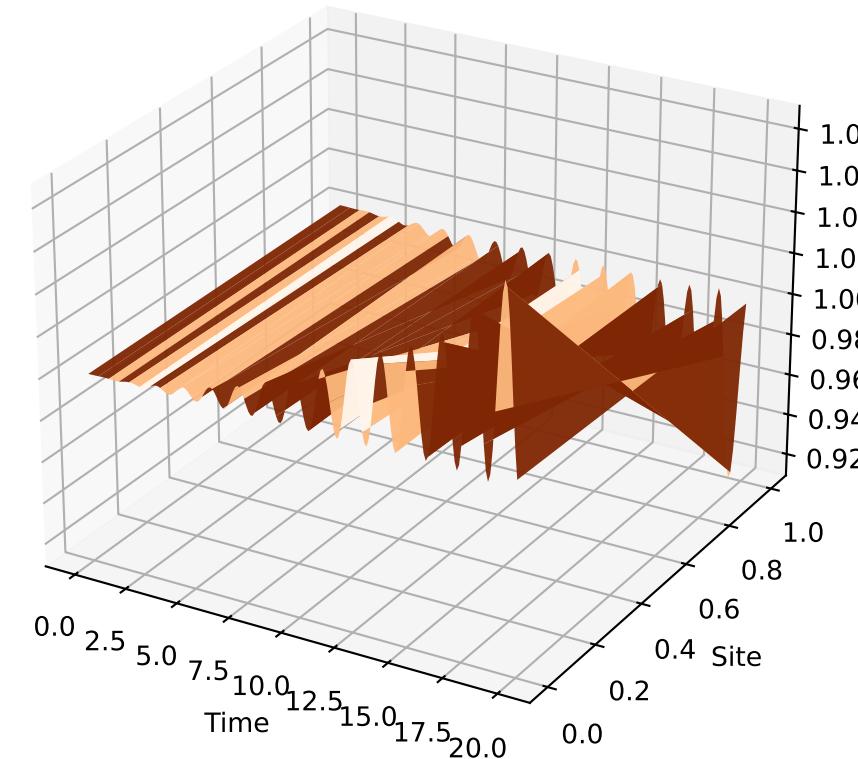
Exact GS Filtered: $n(\text{site}, t)$



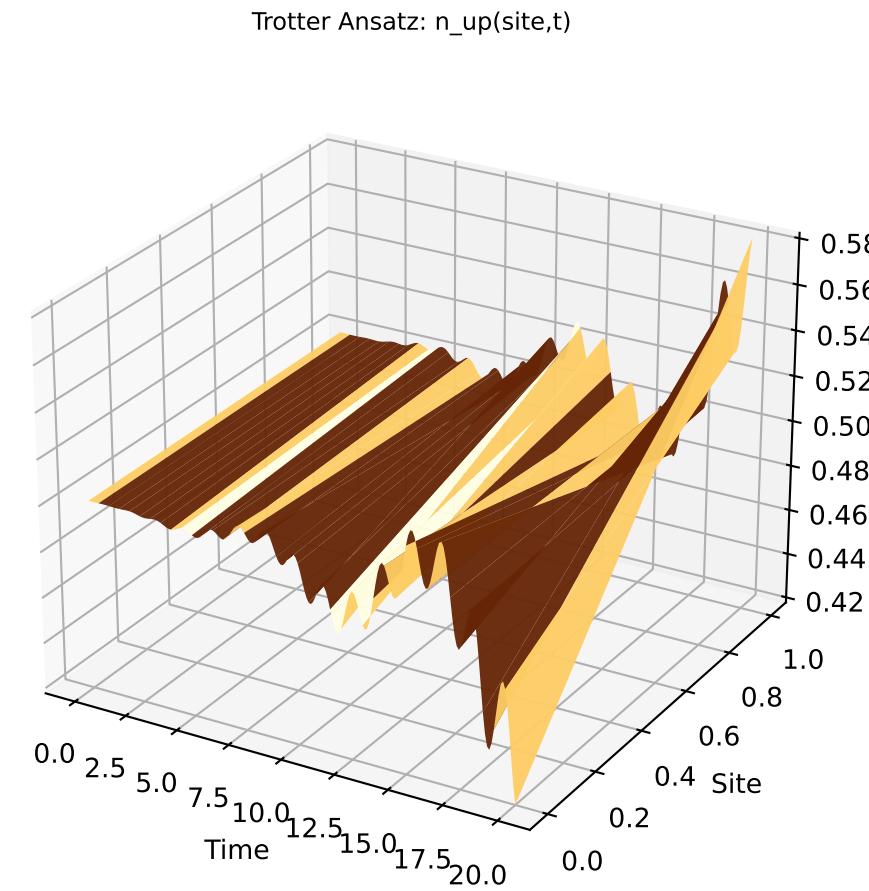
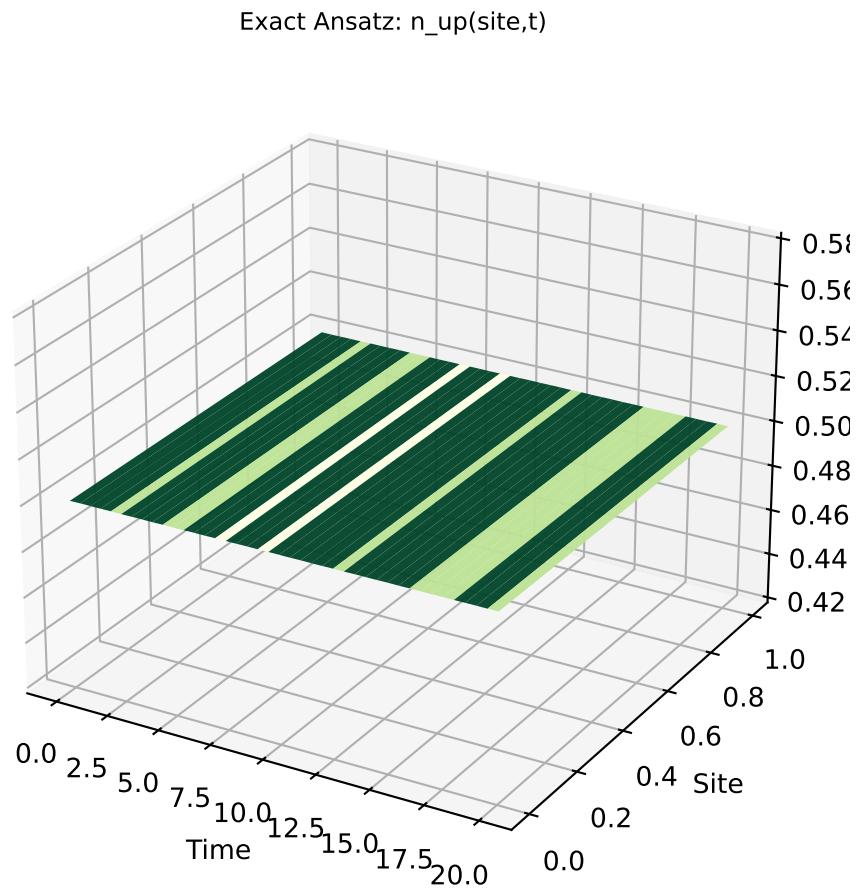
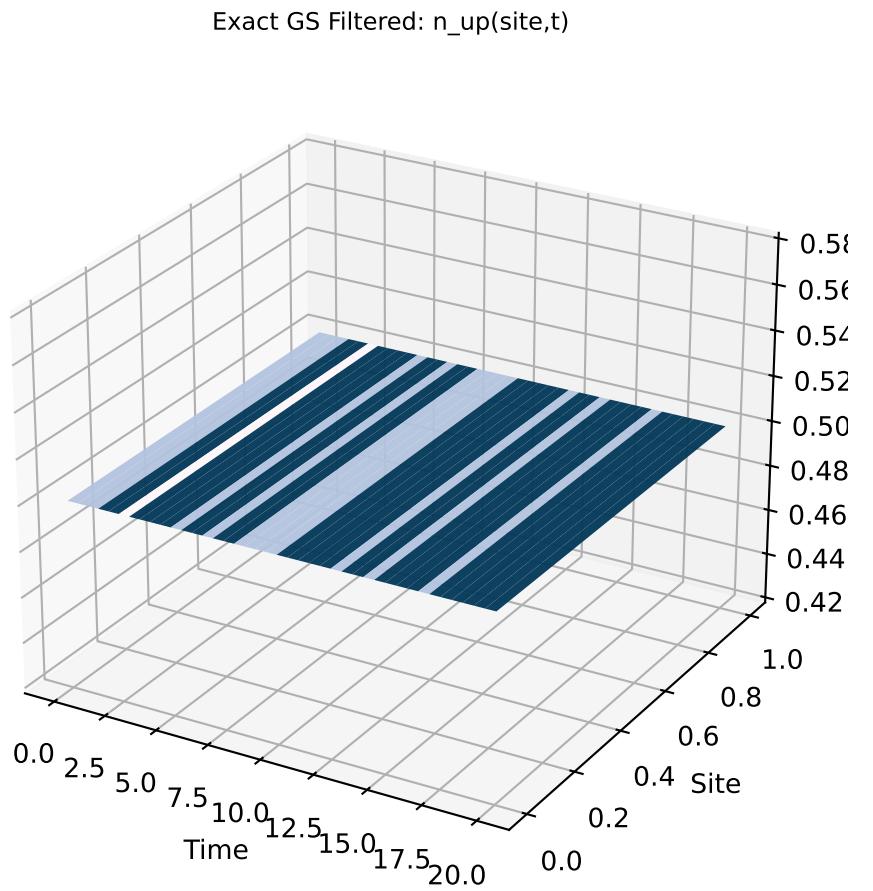
Exact Ansatz: $n(\text{site}, t)$



Trotter Ansatz: $n(\text{site}, t)$

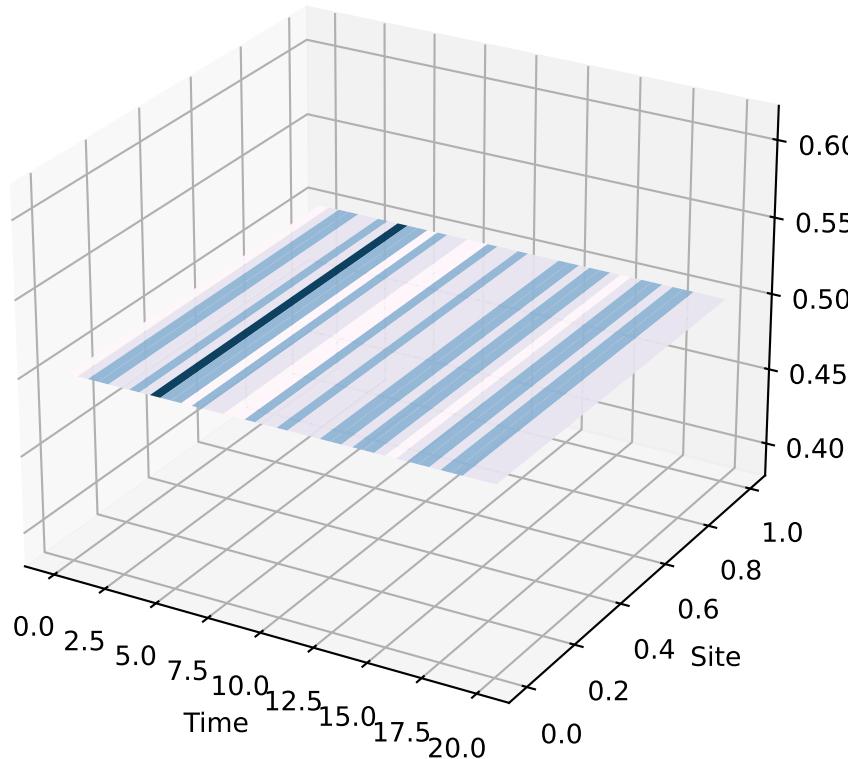


L=2 3D Densities (Spin-Up)

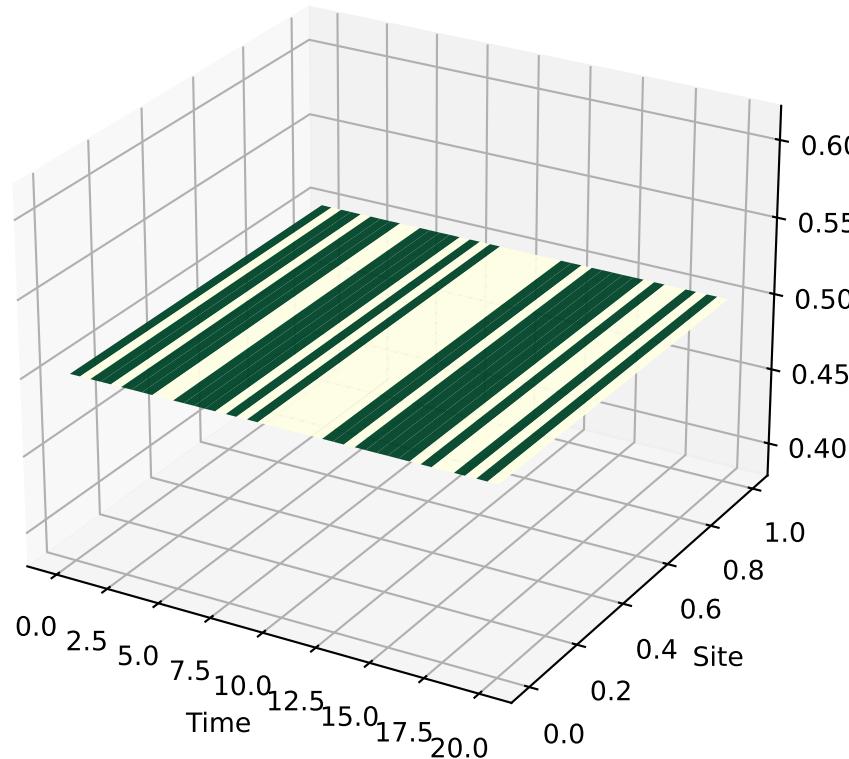


L=2 3D Densities (Spin-Down)

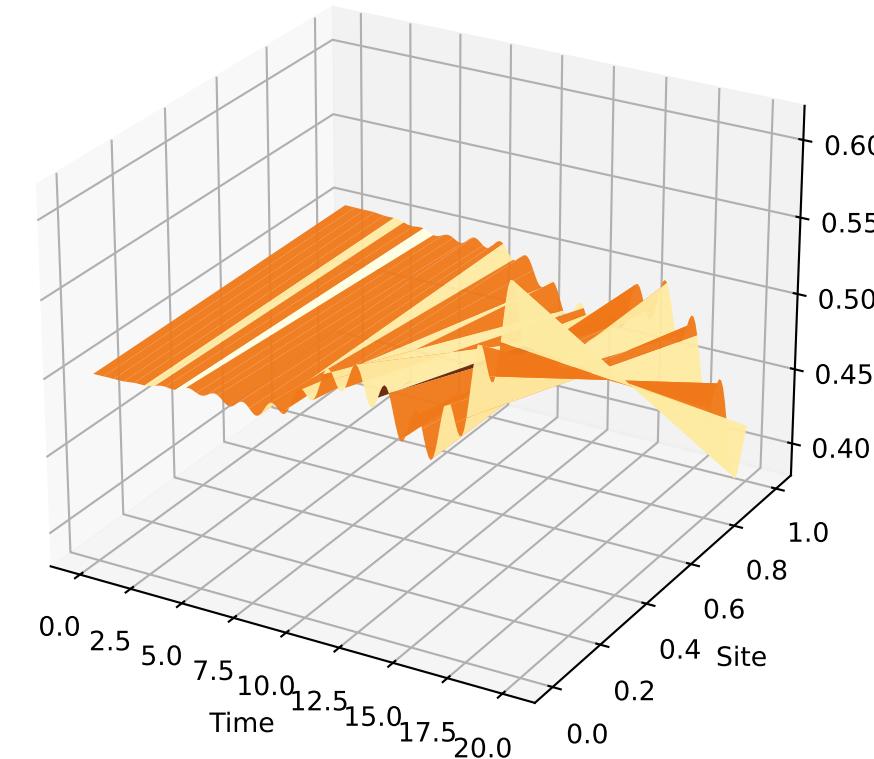
Exact GS Filtered: $n_{dn}(site,t)$



Exact Ansatz: $n_{dn}(site,t)$

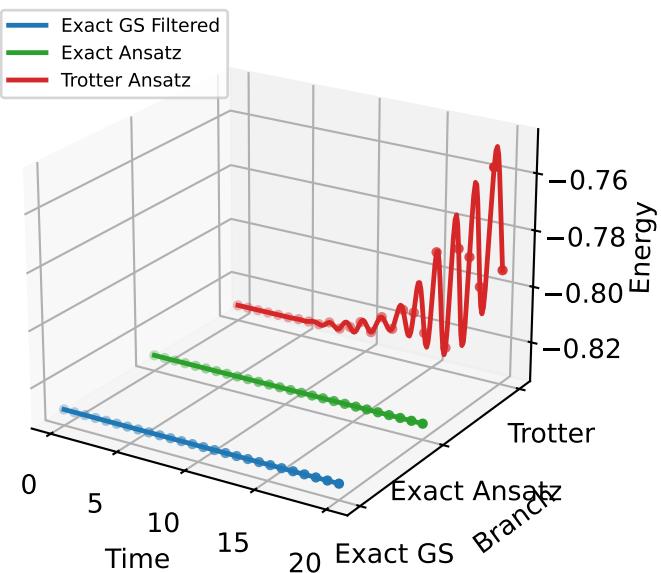


Trotter Ansatz: $n_{dn}(site,t)$

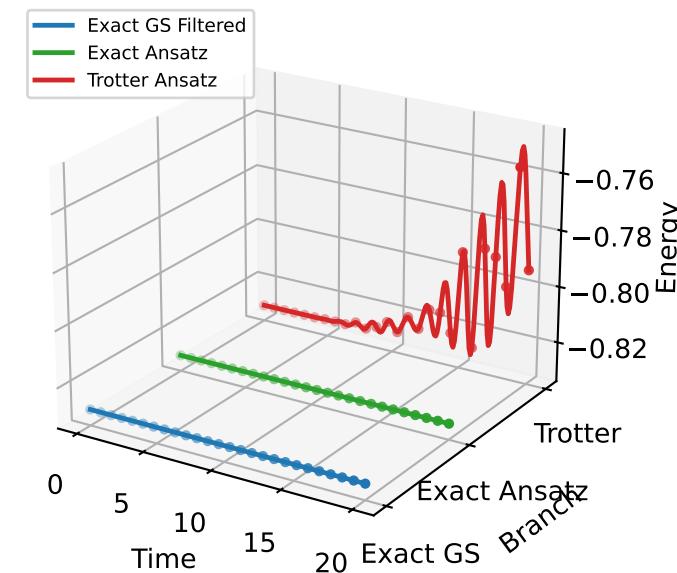


L=2 3D Scalar Observables (Three Evolutions)

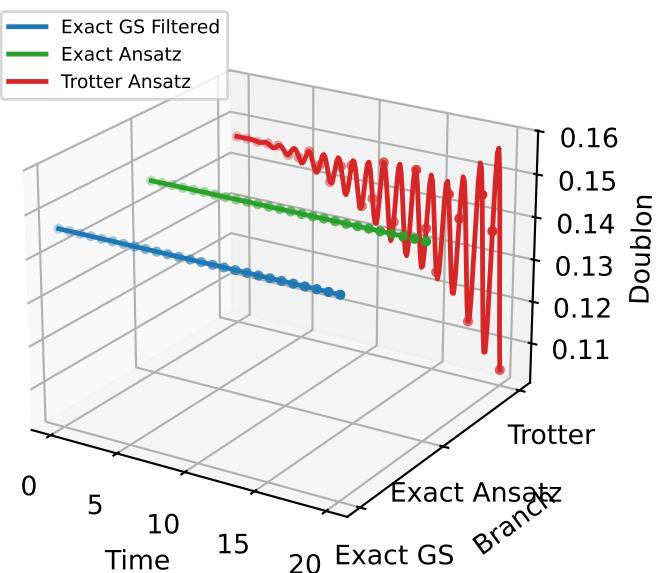
3D Lanes: Total Energy



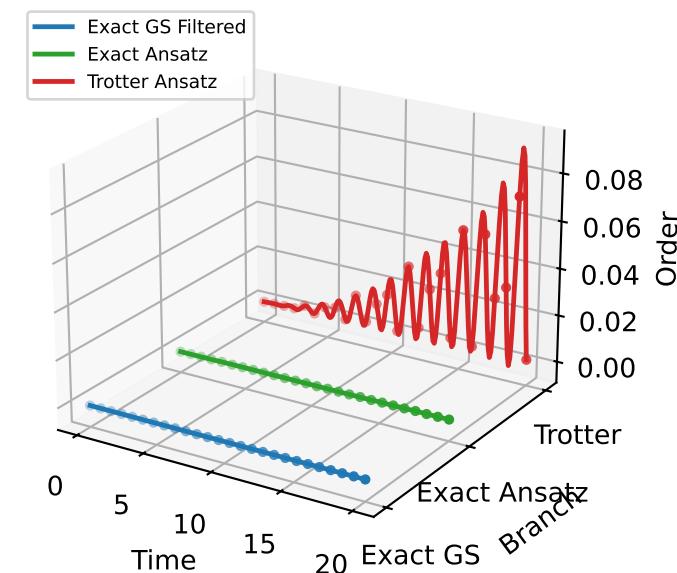
3D Lanes: Static Energy



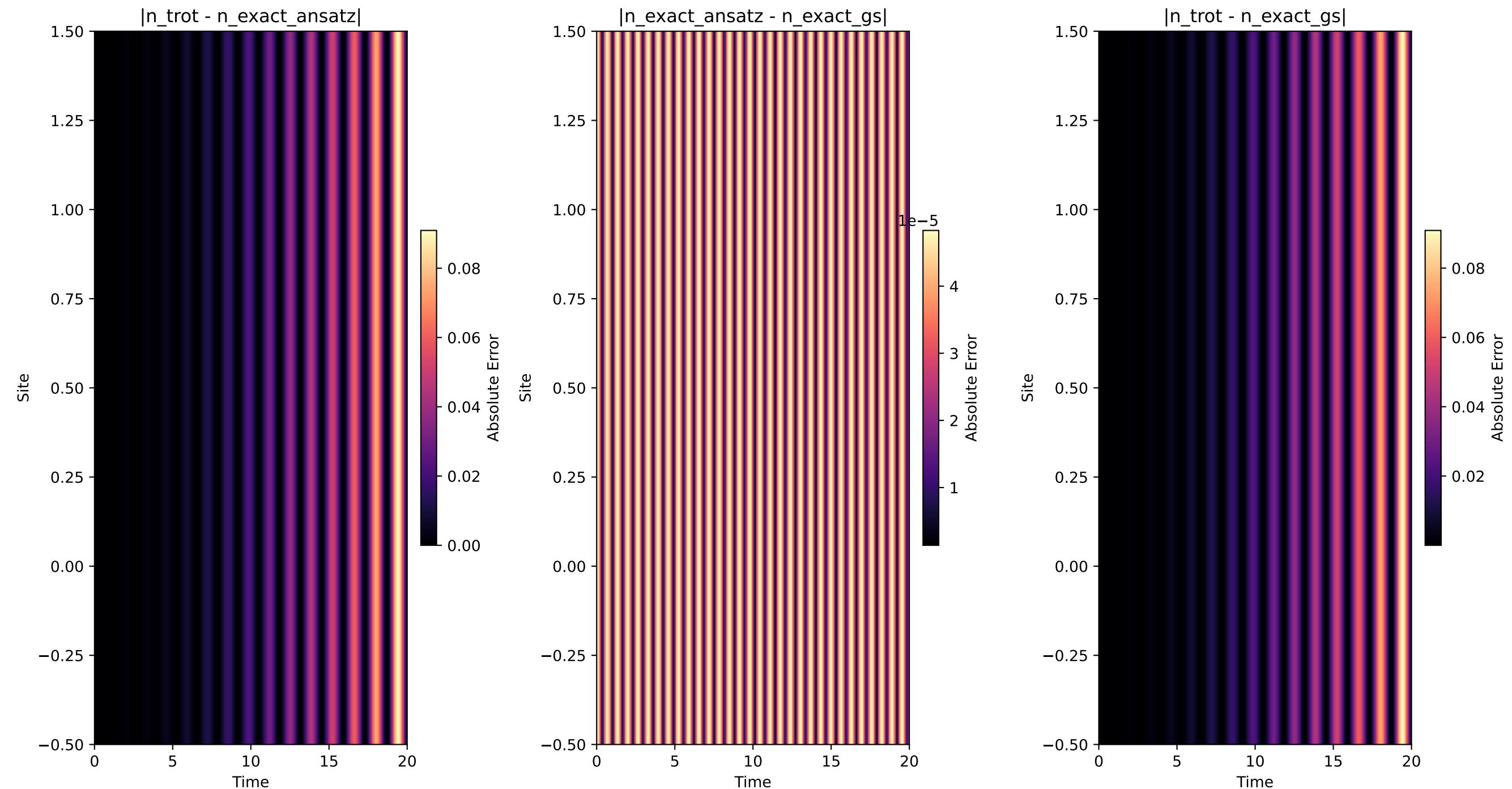
3D Lanes: Doublon



3D Lanes: Staggered Order

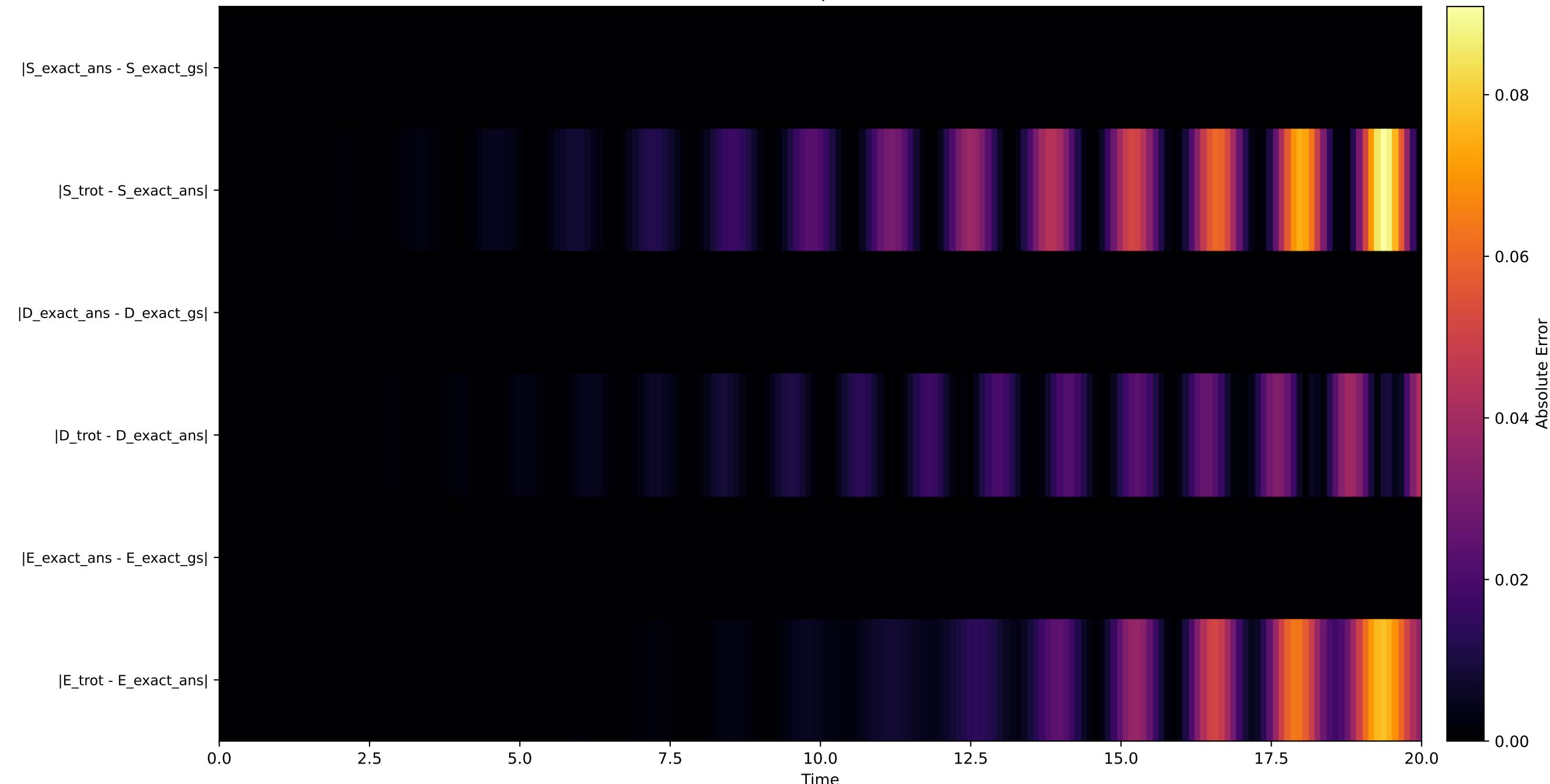


L=2 Error Heatmaps (Absolute Errors)

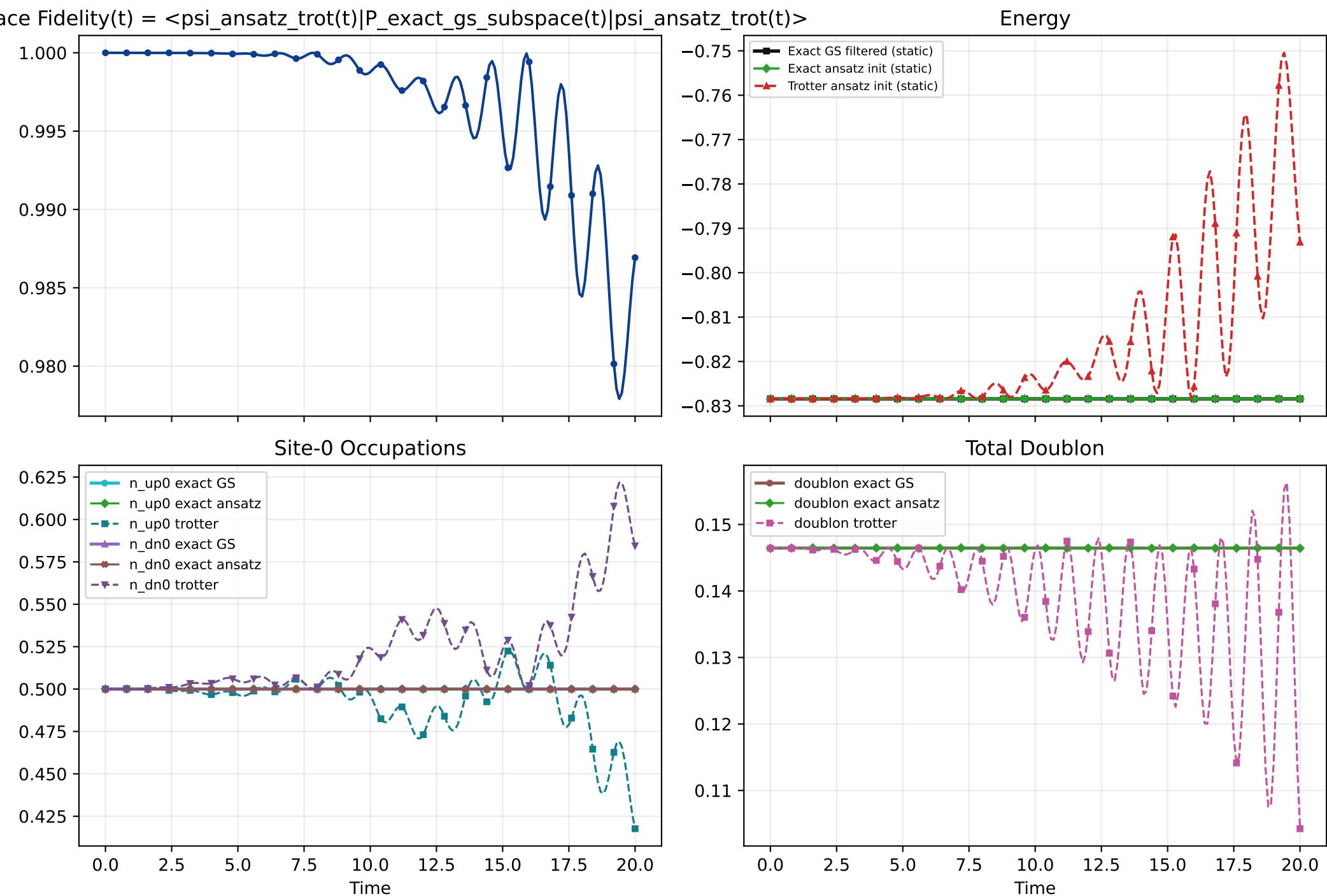


L=2 Scalar Error Heatmap

Absolute Error Heatmap (Scalar Observables)



Hardcoded Hubbard Pipeline: L=2

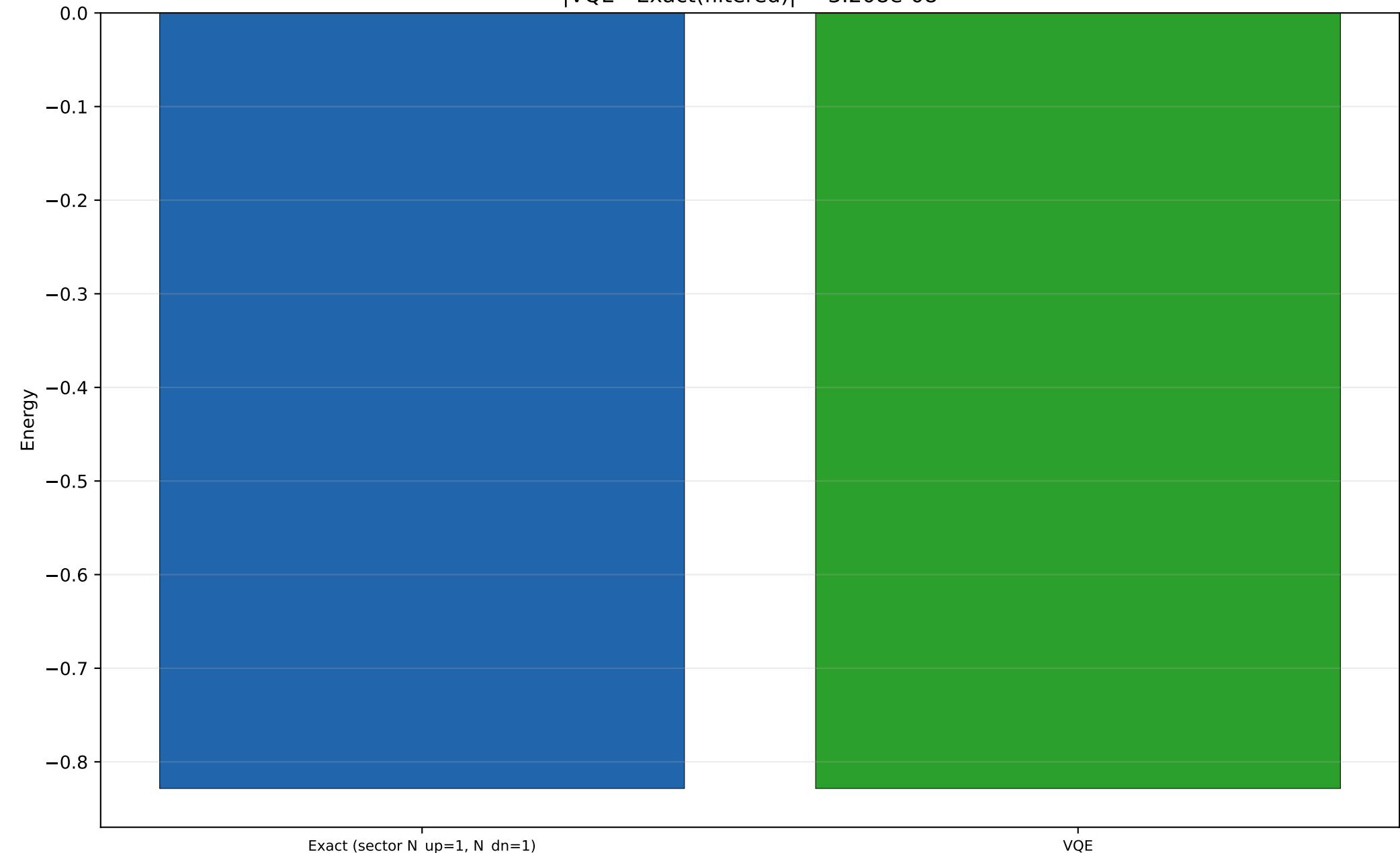


Appendix – L=2

This section contains supporting/redundant views and metadata.
Core non-redundant analysis appears earlier in the PDF.

VQE optimises within the half-filled sector; exact (filtered) is the true sector ground state.
Full-Hilbert exact energy is in the JSON text summary only.

VQE Energy vs Exact (filtered sector)
 $|VQE - \text{Exact(filtered)}| = 3.208e-08$



Hardcoded Hubbard pipeline summary

```
settings: {"L": 2, "t": 1.0, "u": 4.0, "dv": 0.0, "boundary": "periodic", "ordering": "blocked", "t_final": 20.0, "num_times": 100}
exact_trajectory_label: Exact_Hardcode
exact_trajectory_method: python_matrix_eigendecomposition
fidelity_definition: fidelity(t) =  $\langle \psi_{\text{ansatz}}(\text{trot}(t)) | P_{\text{exact\_gs}}(\text{subspace}(t)) | \psi_{\text{ansatz}}(\text{trot}(t)) \rangle$ , where  $P_{\text{exact\_gs}}(\text{subspace}(t))$  is the projector onto the exact ground state subspace
subspace_fidelity_at_t0: 0.9999999932870716
energy_t0_exact_gs: -0.8284271247461902
energy_t0_exact_ansatz: -0.8284270926619848
energy_t0_trotter: -0.828427092661985
ground_state_exact_energy (full Hilbert): -1.000000000000
ground_state_exact_energy_filtered: -0.8284271247461901
filtered_sector: {'n_up': 1, 'n_dn': 1}
vqe_energy: -0.8284270926619854
qpe_energy_estimate: None
initial_state_source: vqe
hamiltonian_terms: 11
reference_sanity: {'checked': False, 'reason': 'no matching bundled reference for these settings'}
```