

#### Executed Command

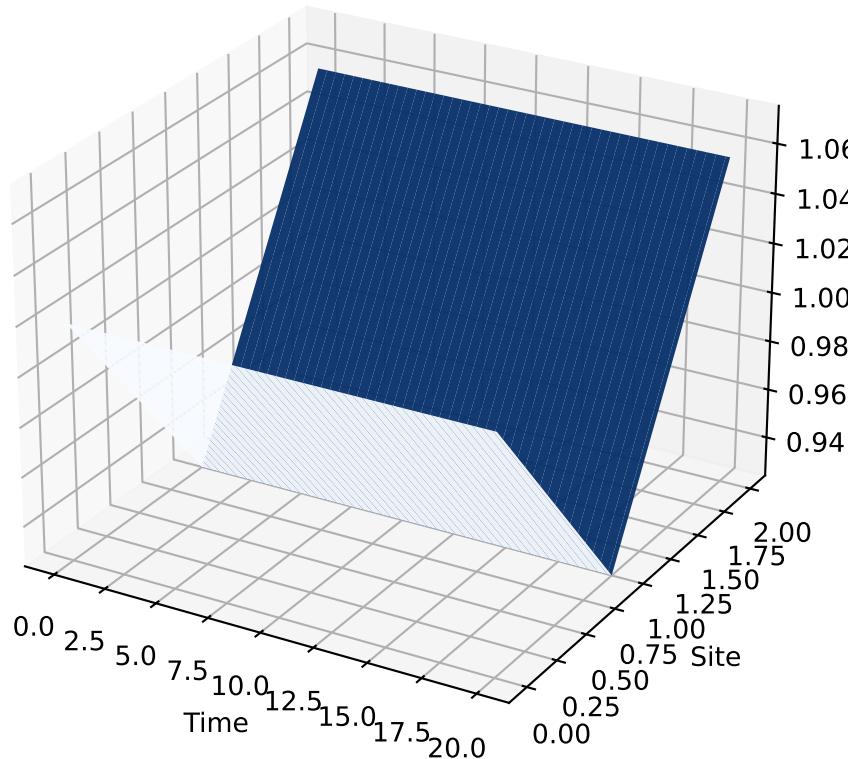
Reference: pipelines/PIPELINE\_RUN\_GUIDE.md

Script: pipelines/hardcoded\_hubbard\_pipeline.py

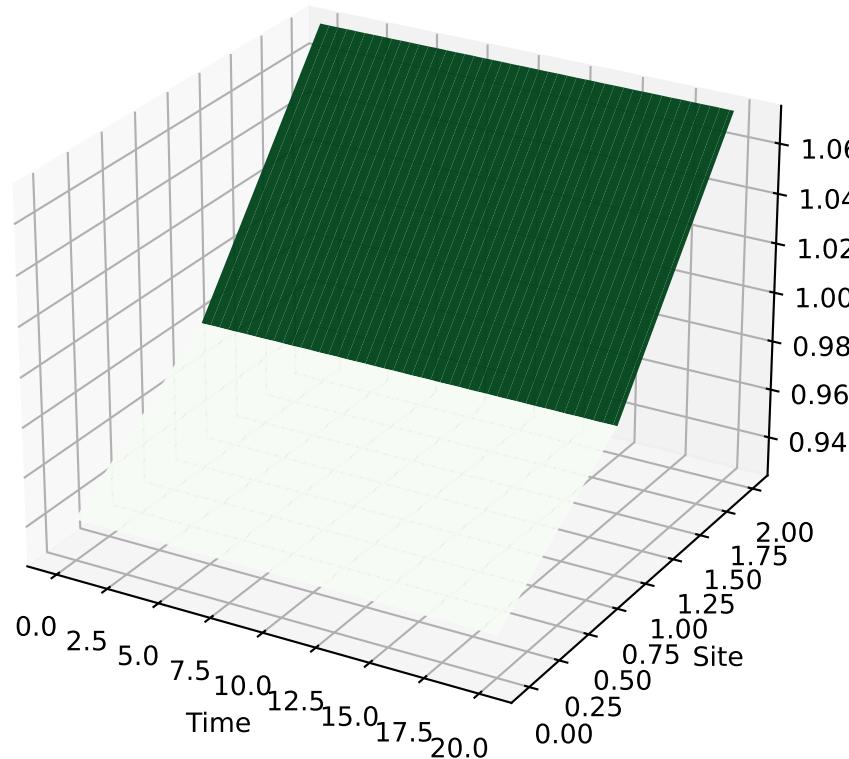
```
/opt/anaconda3/bin/python pipelines/hardcoded_hubbard_pipeline.py --L 3 --t 1.0 --u 4.0 --dv 0.0 --boundary
periodic --ordering blocked --t-final 20.0 --num-times 401 --suzuki-order 2 --trotter-steps 128 --term-order
sorted --vqe-reps 2 --vqe-restarts 3 --vqe-maxiter 600 --skip-qpe --initial-state-source vqe --fidelity-
subspace-energy-tol 1e-8 --output-json artifacts/json/H_L3_static_t1.0_U4.0_S128_heavy.json --output-pdf
artifacts/pdf/H_L3_static_t1.0_U4.0_S128_heavy.pdf
```

### L=3 3D Densities (Total n)

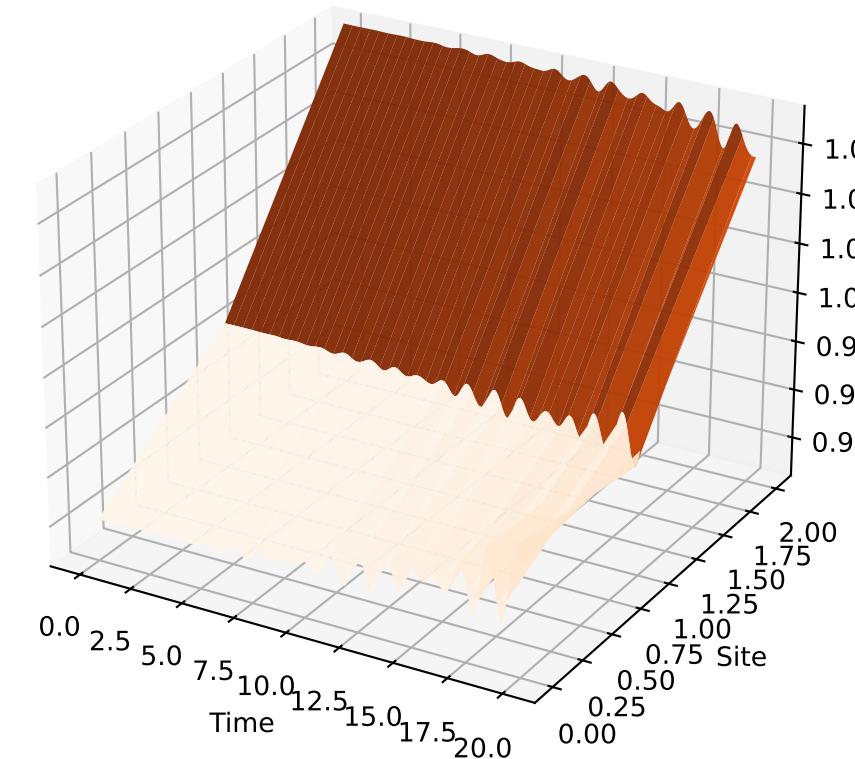
Exact GS Filtered:  $n(\text{site}, t)$



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

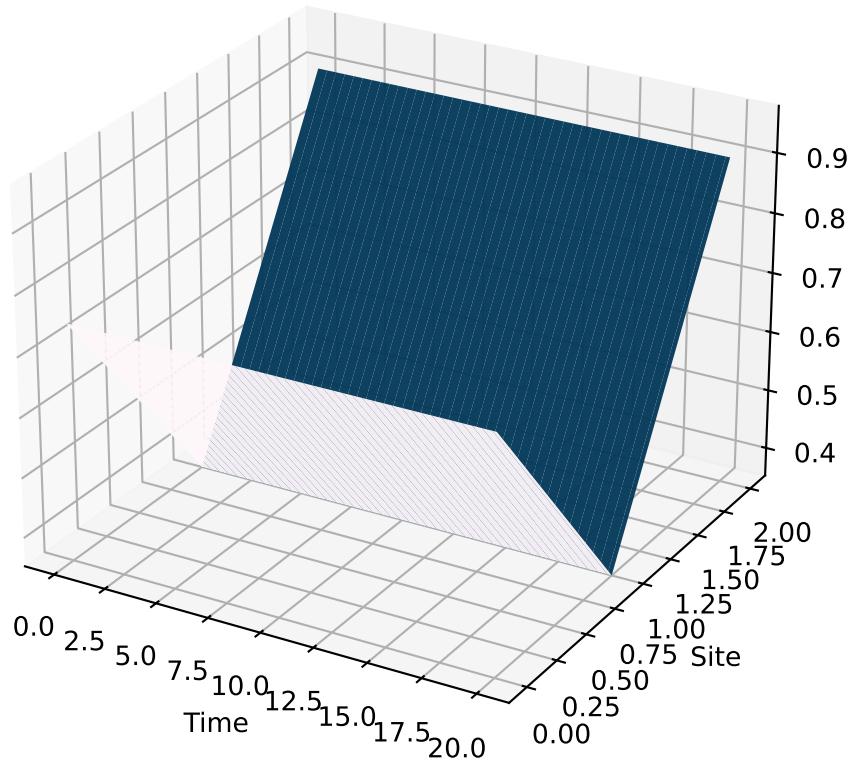


Trotter Ansatz:  $n(\text{site}, t)$

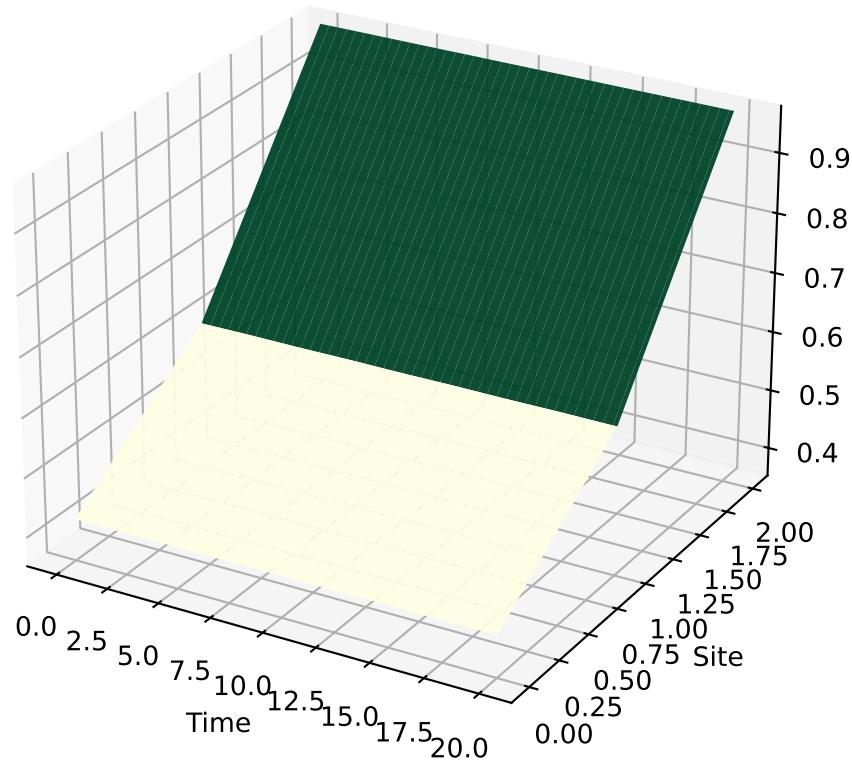


### L=3 3D Densities (Spin-Up)

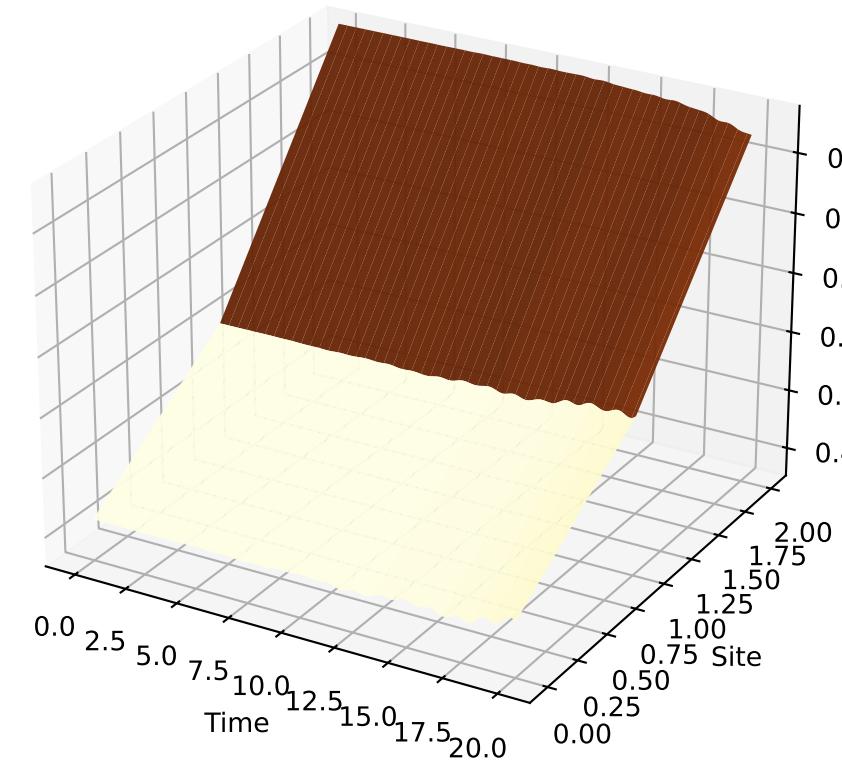
Exact GS Filtered:  $n_{\text{up}}(\text{site}, t)$



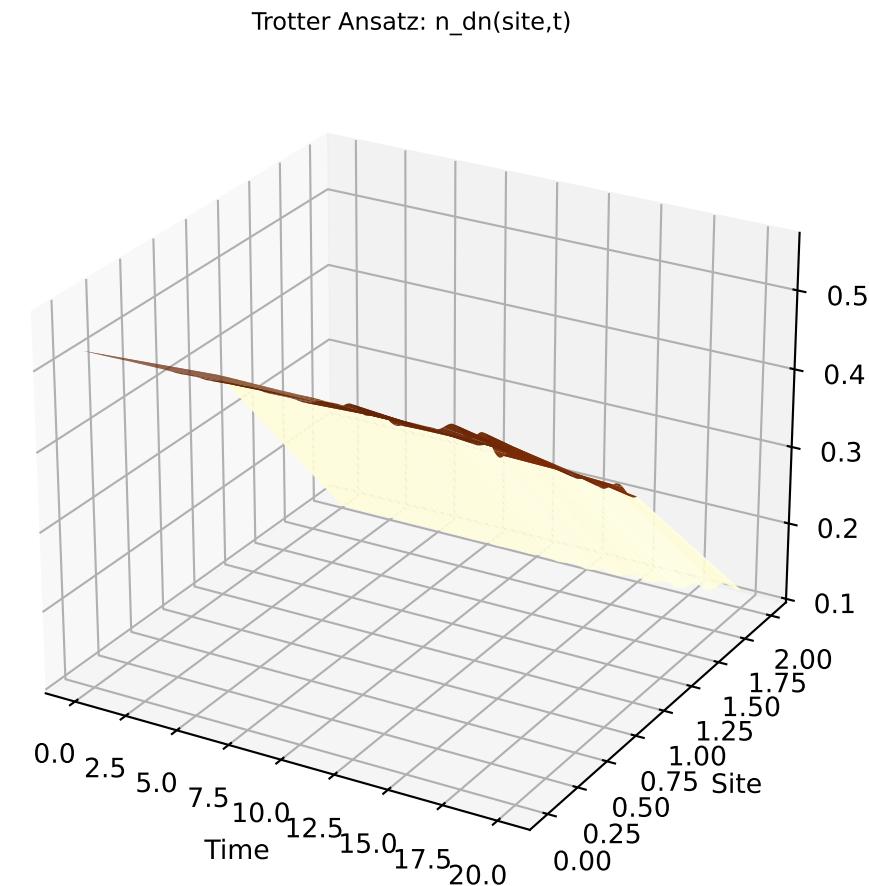
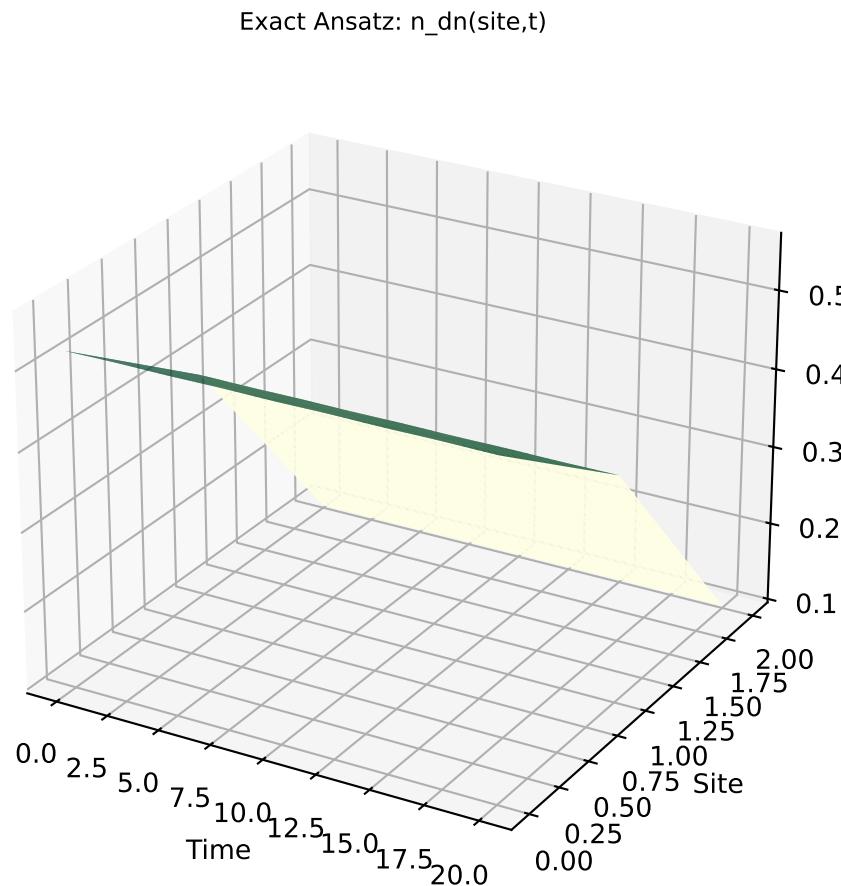
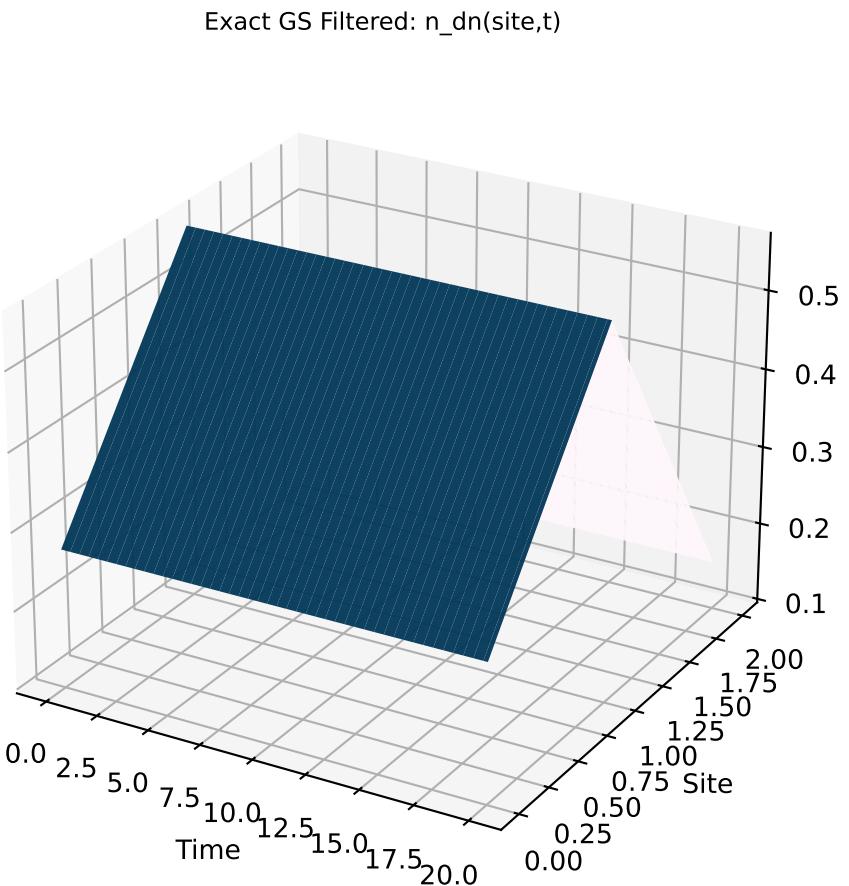
Exact Ansatz:  $n_{\text{up}}(\text{site}, t)$



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

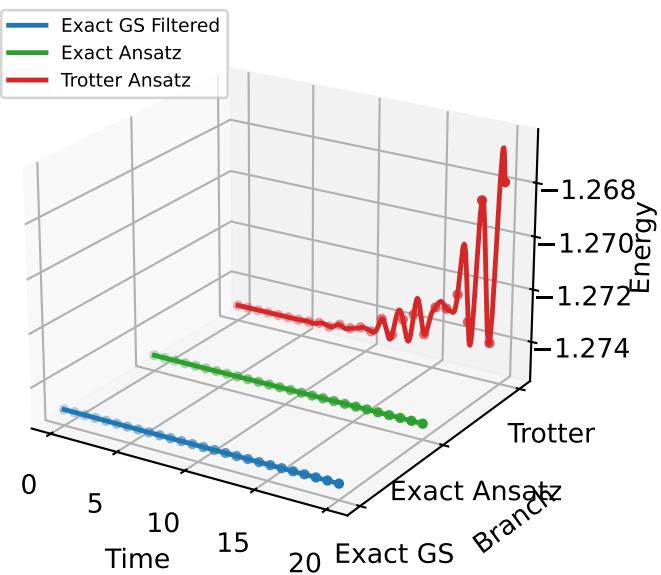


### L=3 3D Densities (Spin-Down)

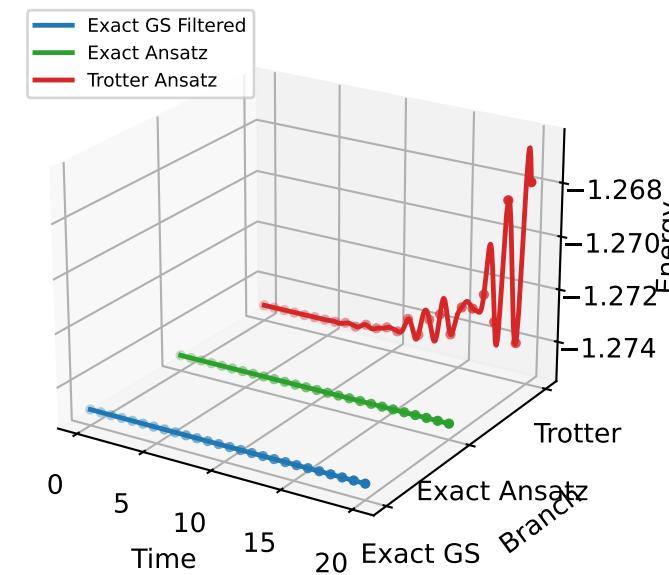


# L=3 3D Scalar Observables (Three Evolutions)

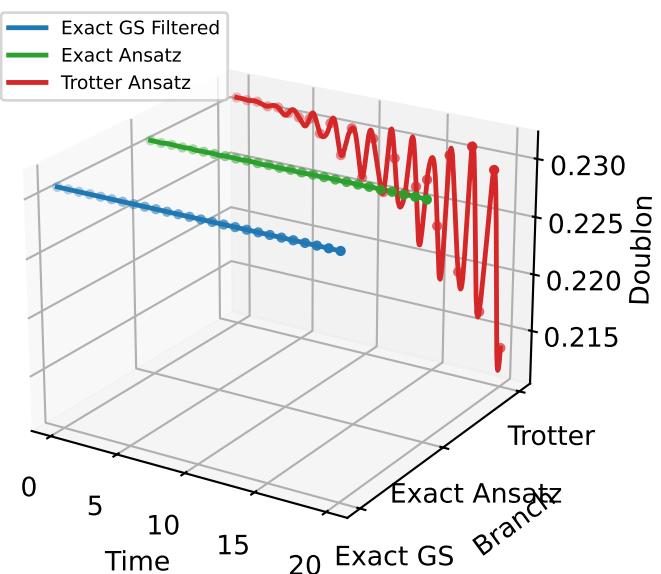
3D Lanes: Total Energy



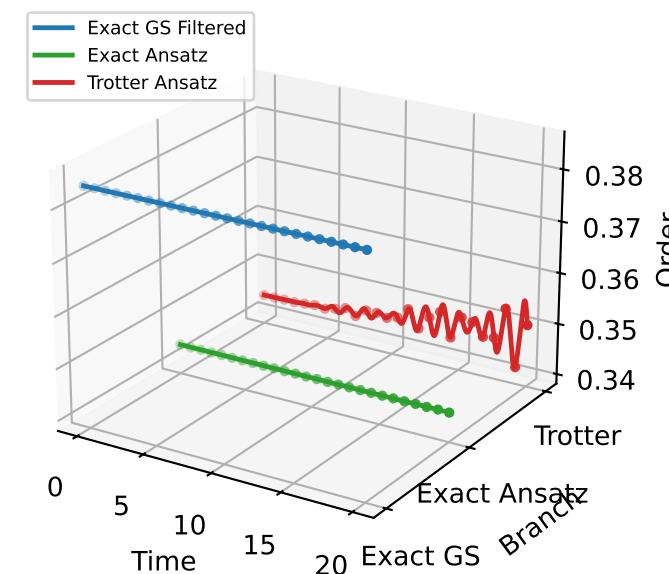
3D Lanes: Static Energy



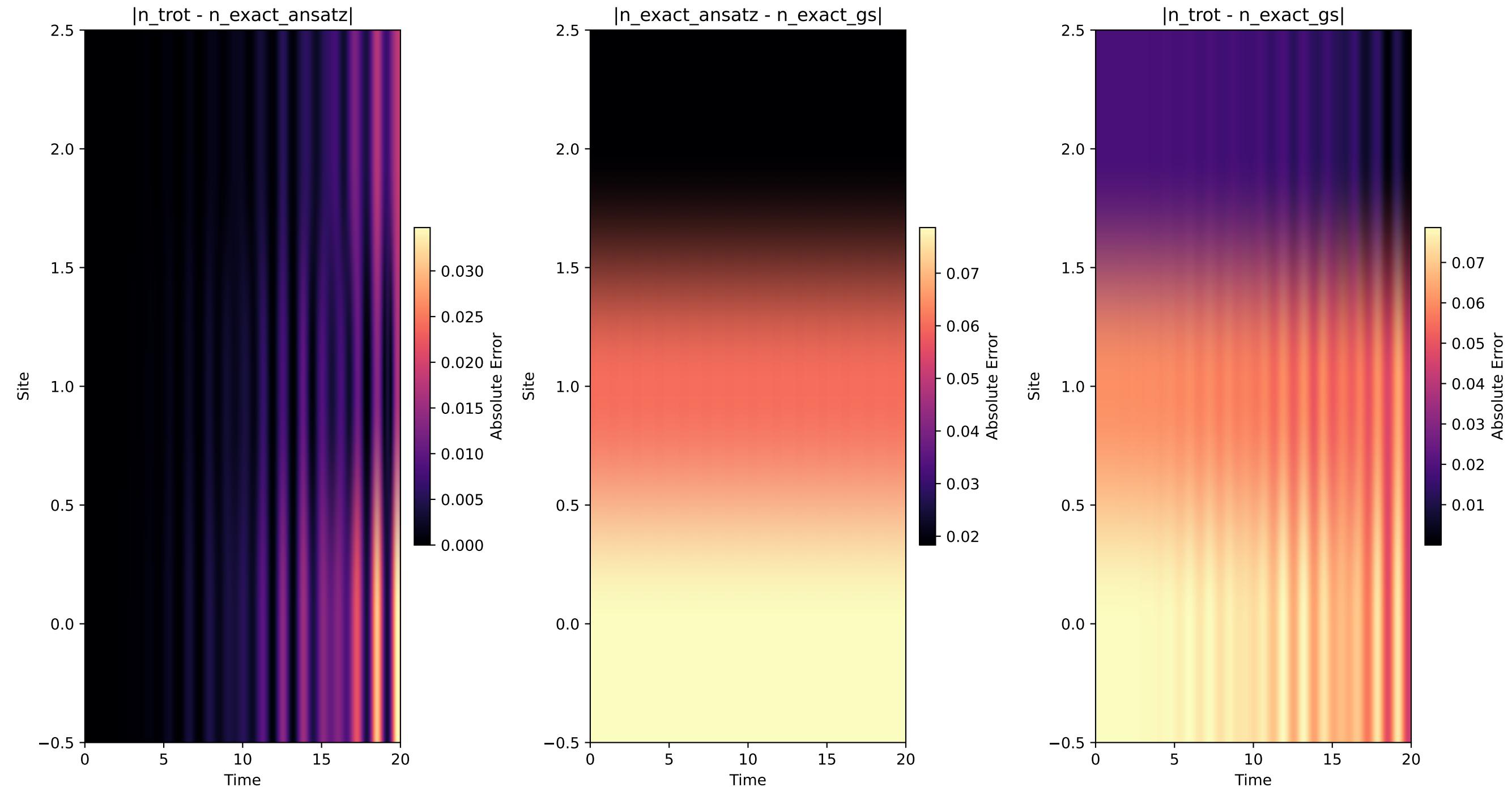
3D Lanes: Doublon



3D Lanes: Staggered Order

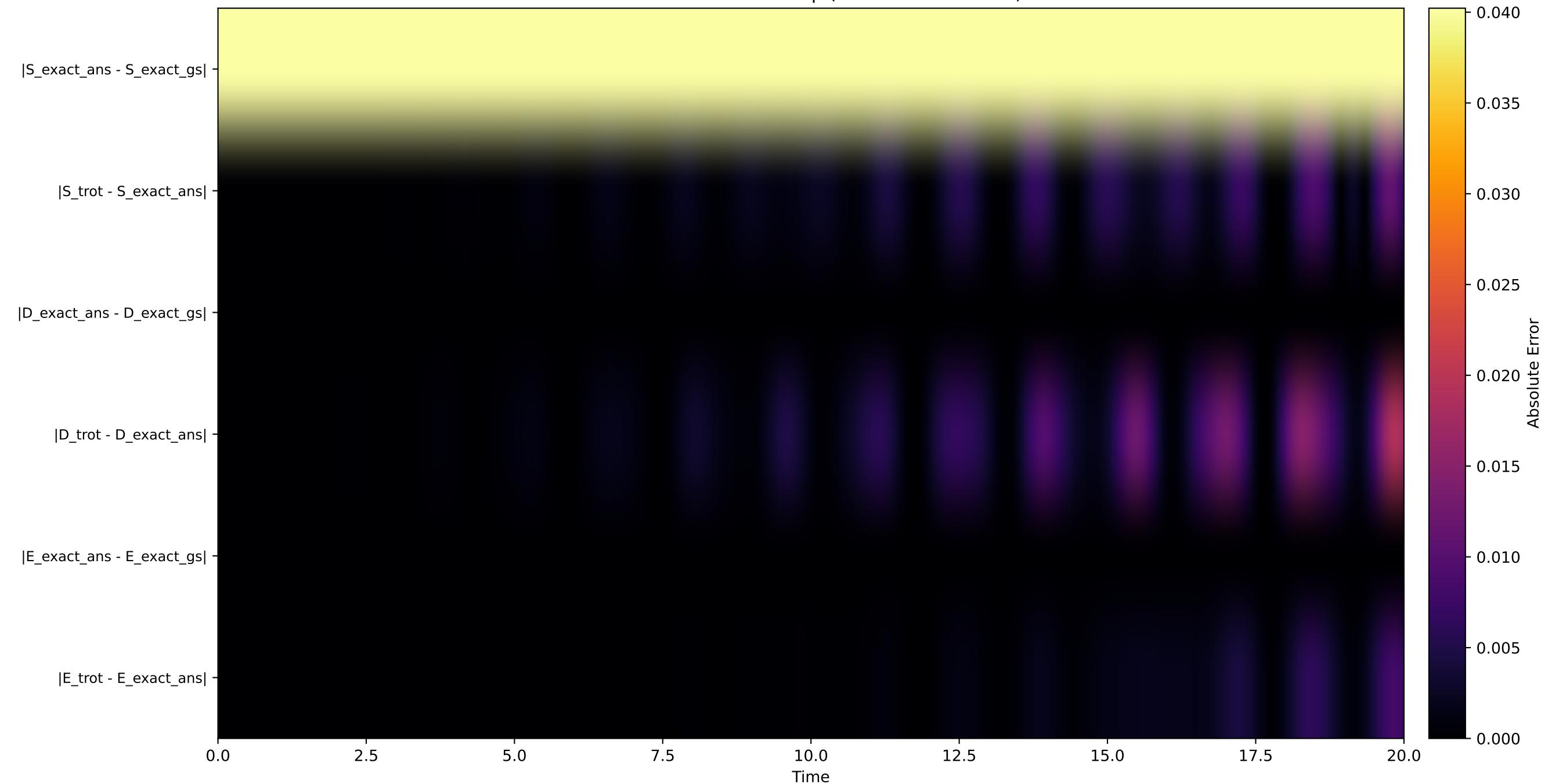


L=3 Error Heatmaps (Absolute Errors)

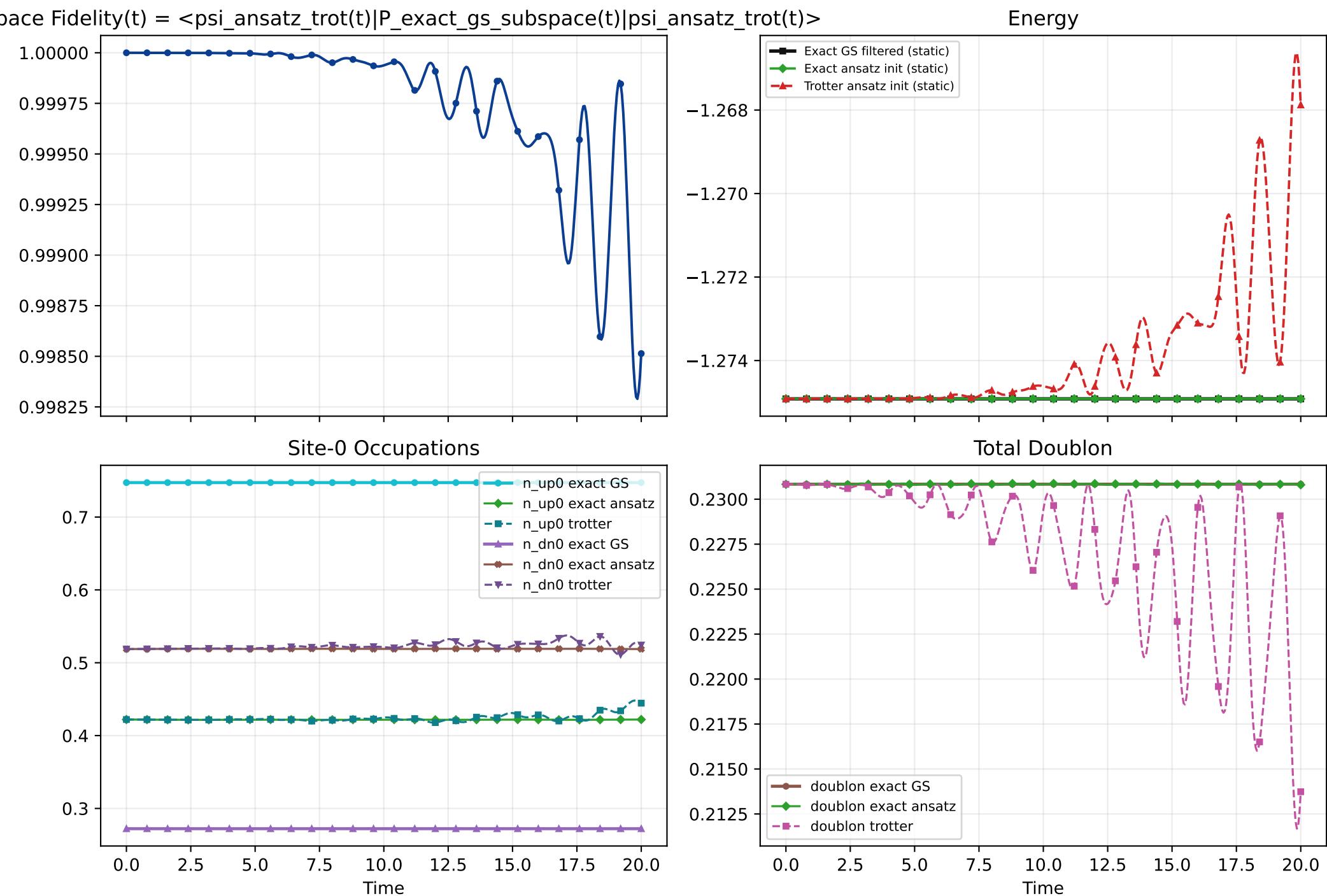


# L=3 Scalar Error Heatmap

Absolute Error Heatmap (Scalar Observables)



# Hardcoded Hubbard Pipeline: L=3

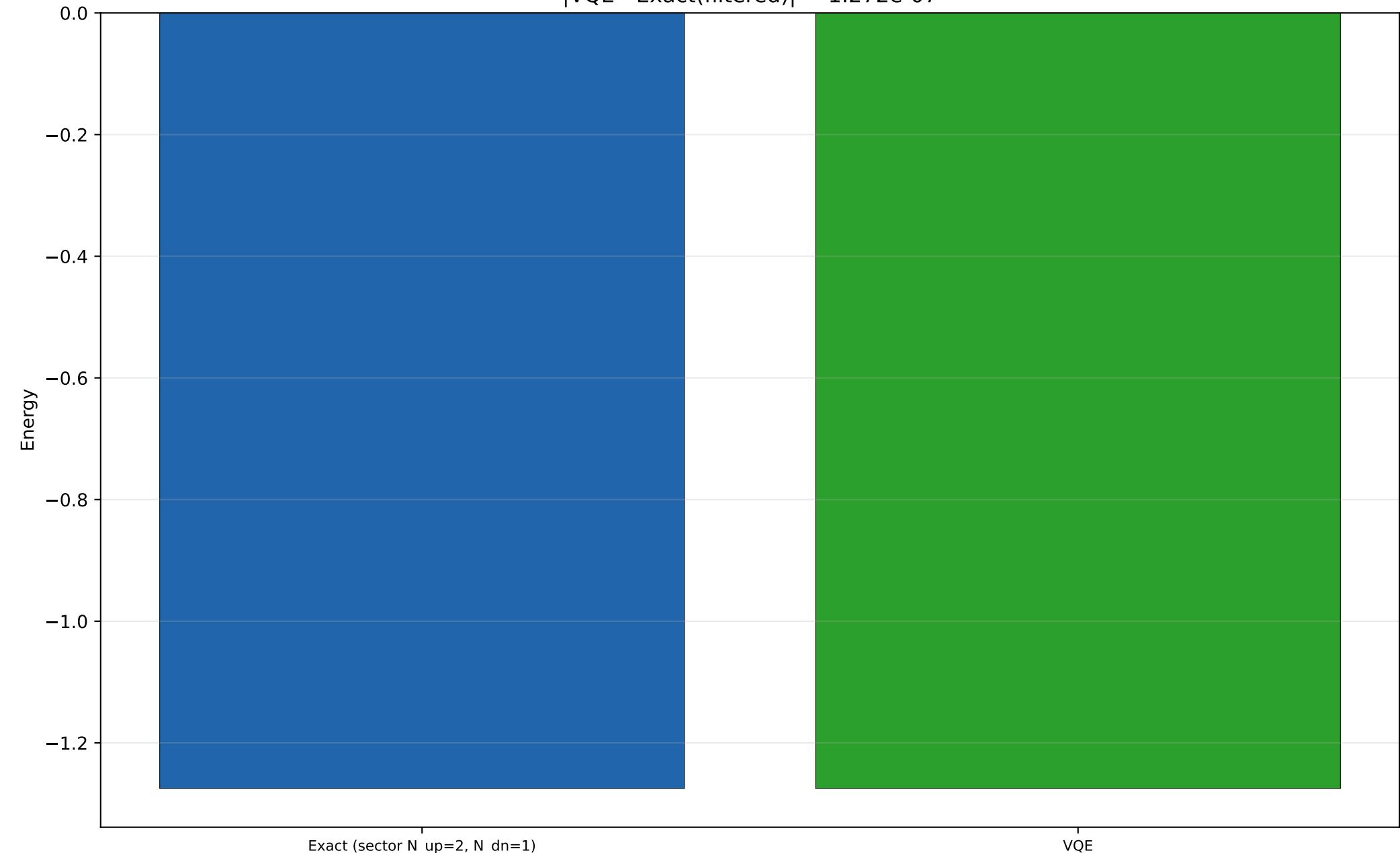


## Appendix – L=3

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)  
 $|VQE - Exact(filtered)| = 1.272e-07$



Hardcoded Hubbard pipeline summary

```
settings: {"L": 3, "t": 1.0, "u": 4.0, "dv": 0.0, "boundary": "periodic", "ordering": "blocked", "t_final": 20.0, "num_times": 1000}
exact_trajectory_label: Exact_Hardcode
exact_trajectory_method: python_matrix_eigendecomposition
fidelity_definition: fidelity(t) = <psi_ansatz_trot(t)|P_exact_gs_subspace(t)|psi_ansatz_trot(t)>, where P_exact_gs_subspace(t) = P_gs @ U(t)
subspace_fidelity_at_t0: 0.9999999180073835
energy_t0_exact_gs: -1.2749172176353754
energy_t0_exact_ansatz: -1.2749170904348224
energy_t0_trotter: -1.2749170904348222
ground_state_exact_energy (full Hilbert): -3.123105625618
ground_state_exact_energy_filtered: -1.2749172176353751
filtered_sector: {'n_up': 2, 'n_dn': 1}
vqe_energy: -1.27491709043483
qpe_energy_estimate: None
initial_state_source: vqe
hamiltonian_terms: 22
reference_sanity: {'checked': False, 'reason': 'no matching bundled reference for these settings'}
```