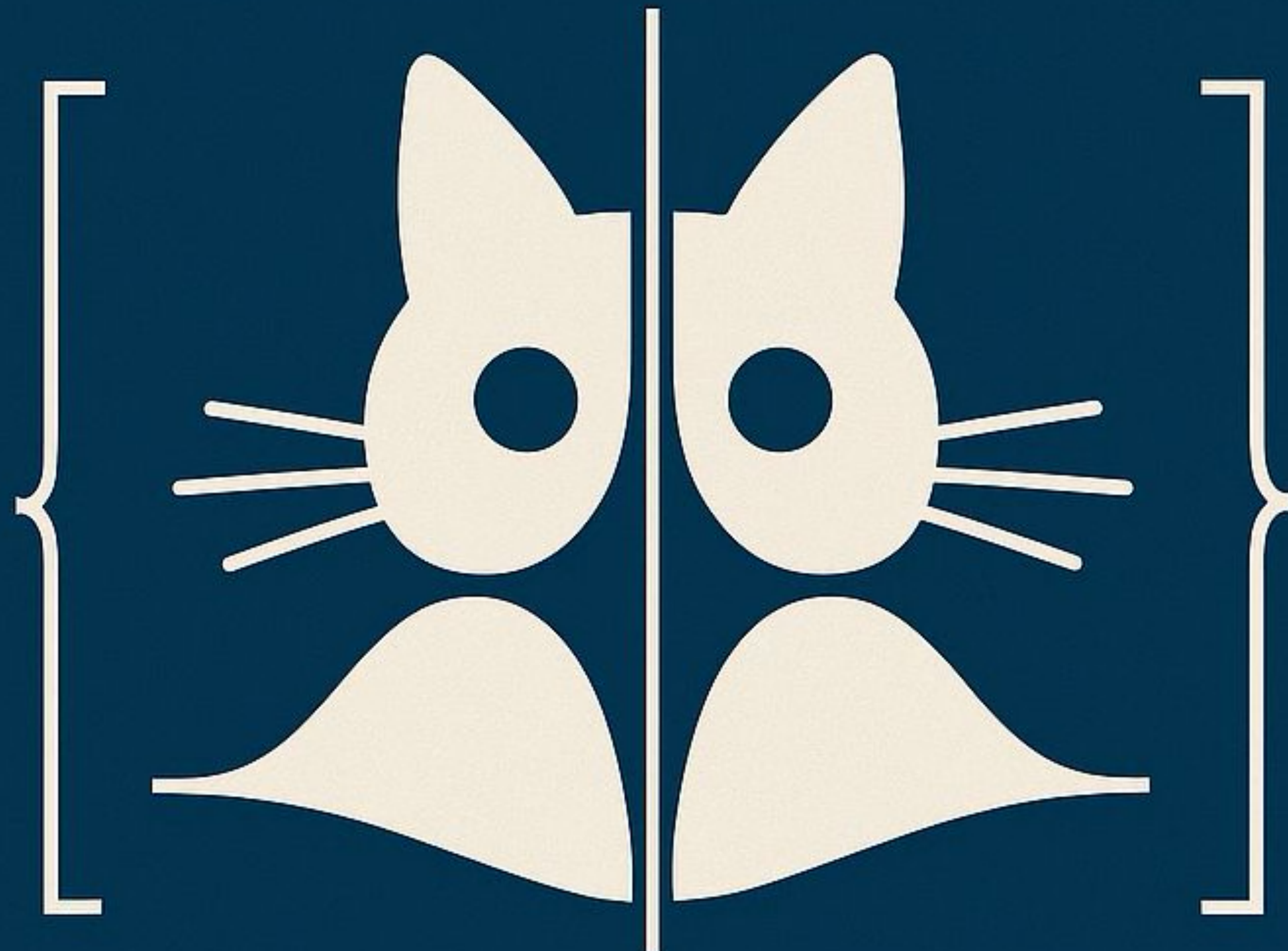
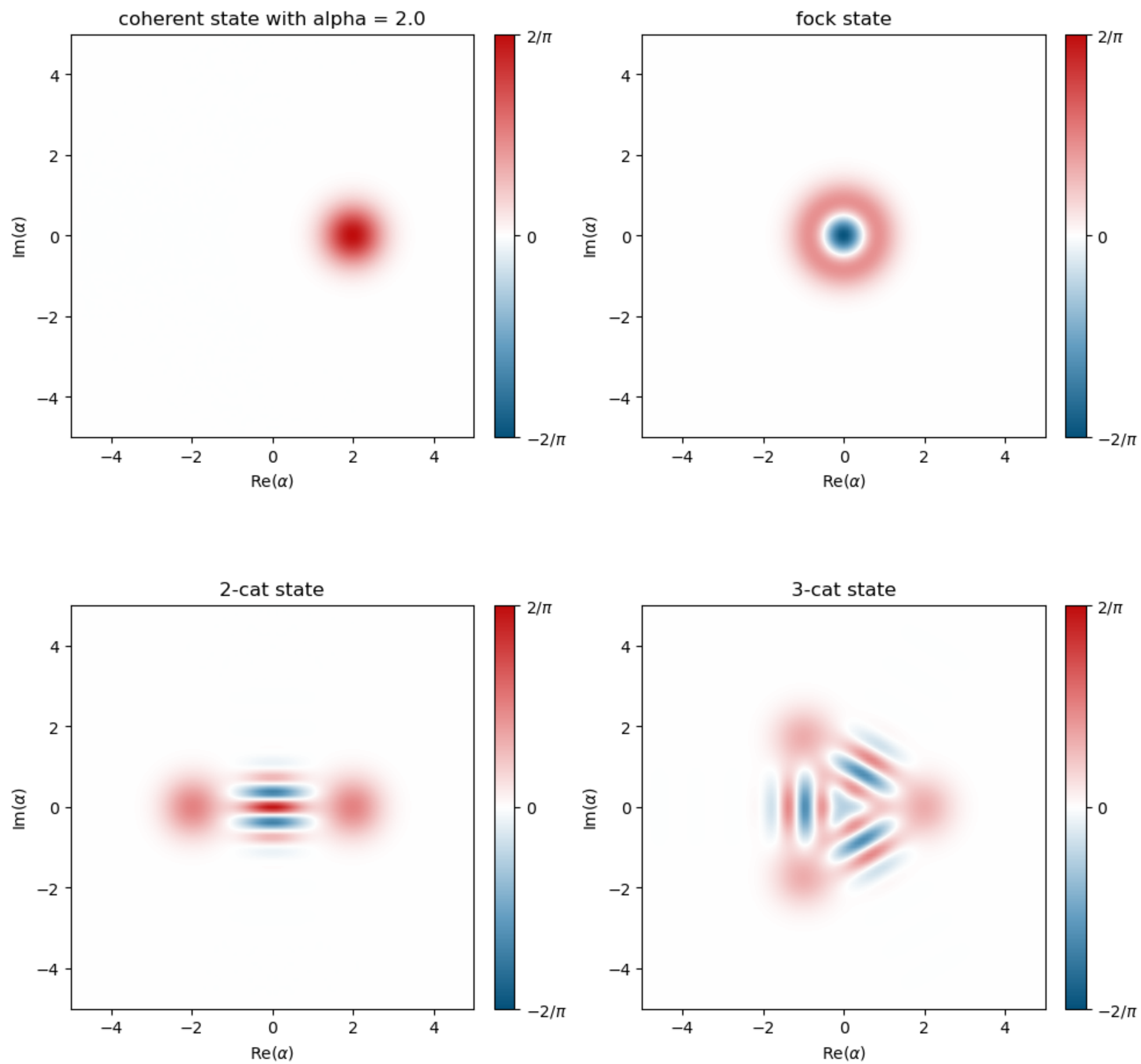
Alain & Bernadette



CAT Qubits

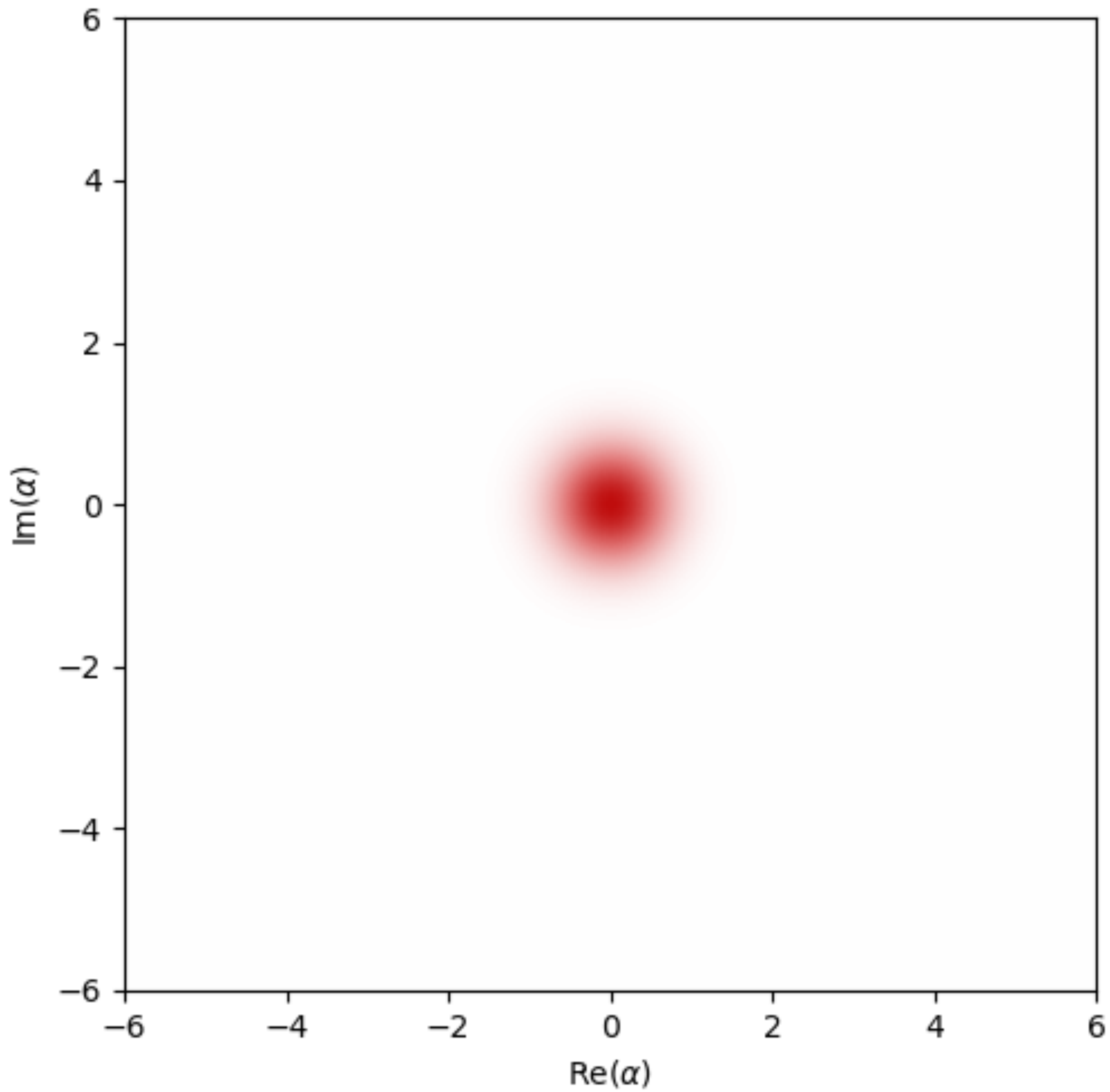
1.A. Generating Wigner Functions

1.A.1. Static Wigner function plots



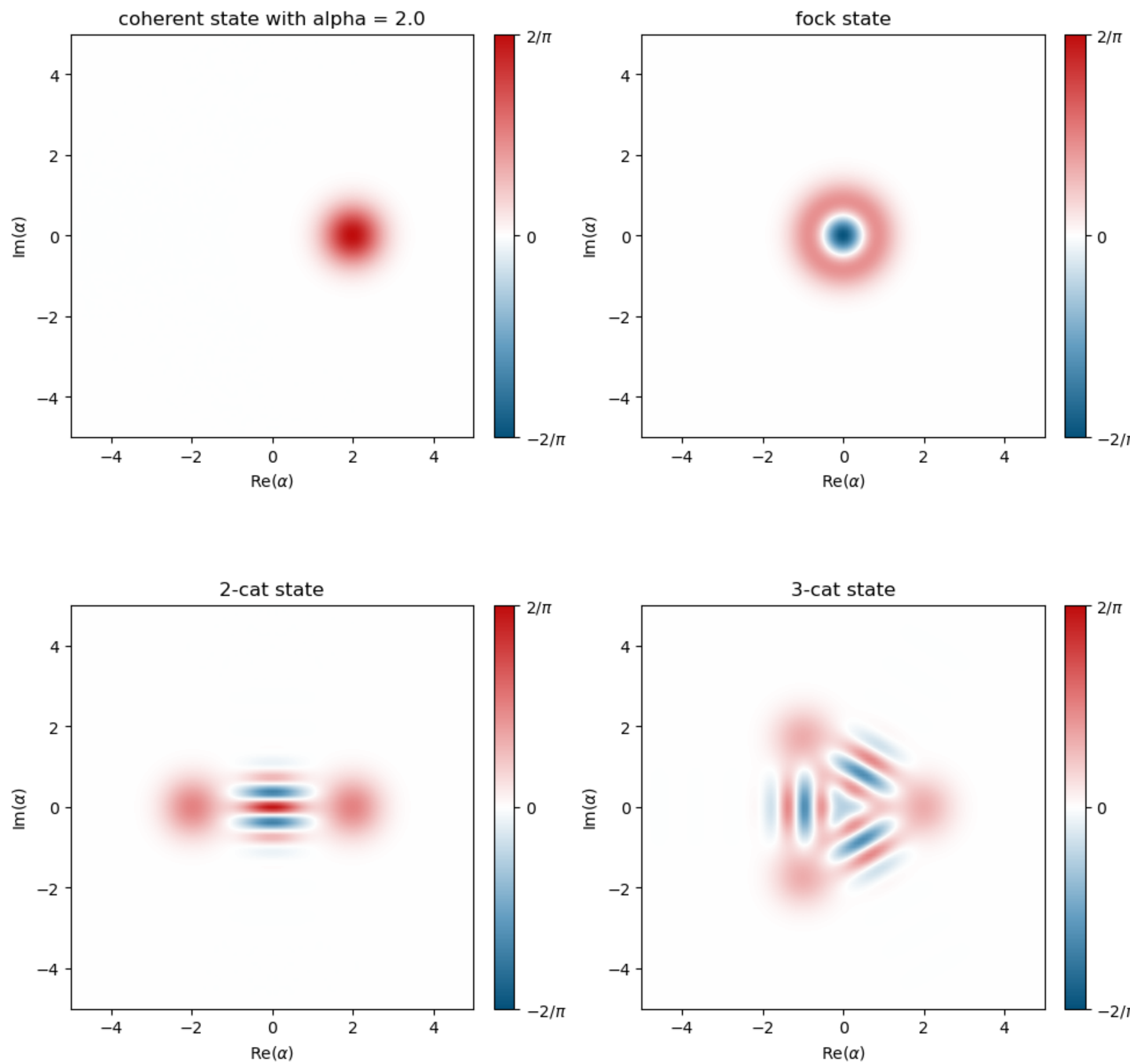
1.A. Generating Wigner Functions

1.A.2 Dissipative cat state's Wigner function



1.B. Density Matrix Reconstruction from Wigner Data

1.A.1. Static Wigner function plots



1.B. Density Matrix Reconstruction from Wigner Data

1.B.1. rho_reconstruction method

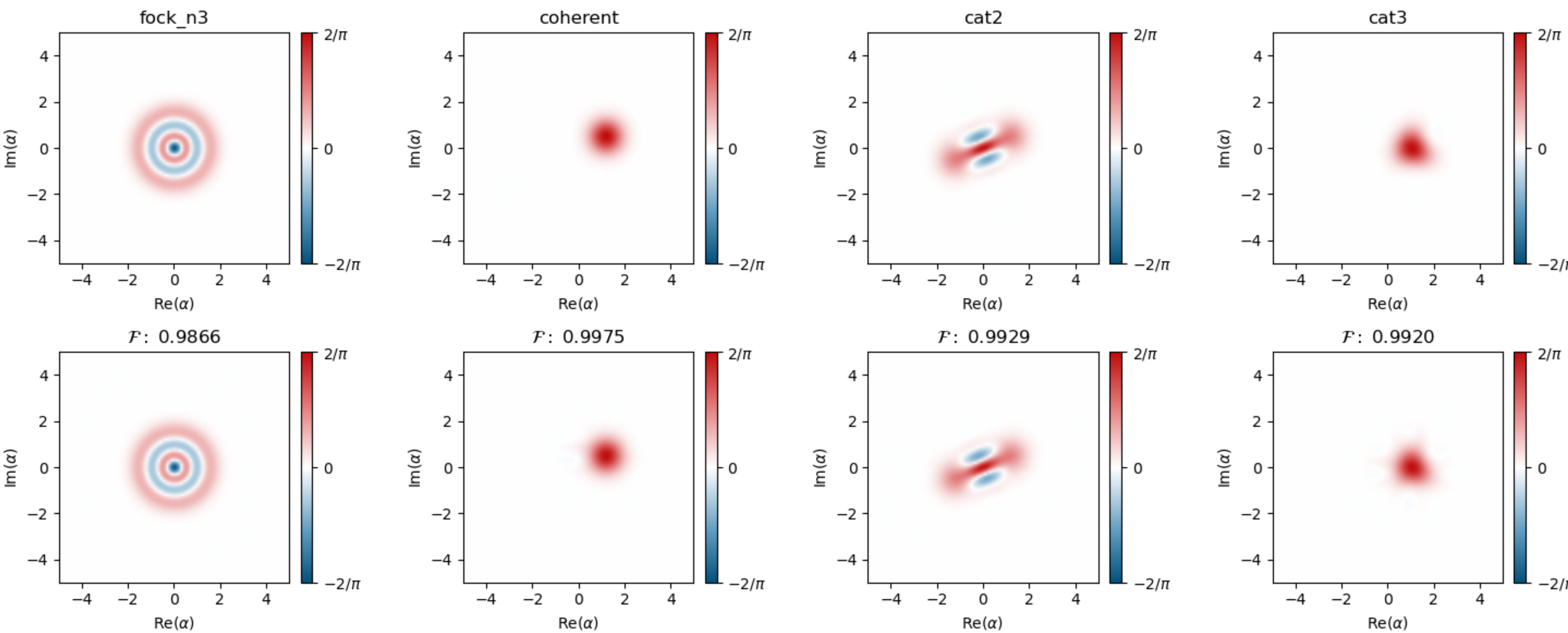
```
def rho_reconstruction(
    W_grid: np.ndarray,
    xvec: np.ndarray,
    pvec: np.ndarray,
    alpha_list: Sequence[complex],
    N_psi: int,
    rho_reference: dq.QArray,
    N_fit: Optional[int] = None,
    solver: str ='SCS',
    objective: str ='sum_squares',
    **kwargs
    ) -> Tuple[dq.QArray, List[float], List[dq.QArray], TomographyMetrics]:
```

- Validate shape of xvec, pvec and W_grid.
- Make a wigner interpolation in the range of xvec and pvec.
- Calculate w_k from alpha_list.
- Calculate E_α from alpha_list.
- Define ρ_{obj} with constrains (cvxpy).
- Calculate $p = \mathrm{Tr}(E_\alpha \rho_{\text{obj}})$
- Minimize using 'objective' $dist(p - w_k)$.
- Get metrics (fidelity, trace distance, etc.)

1.B. Density Matrix Reconstruction from Wigner Data

1.B.2-3. Synthetic data

N = 30   N fit = 100 α points: 200 x 200

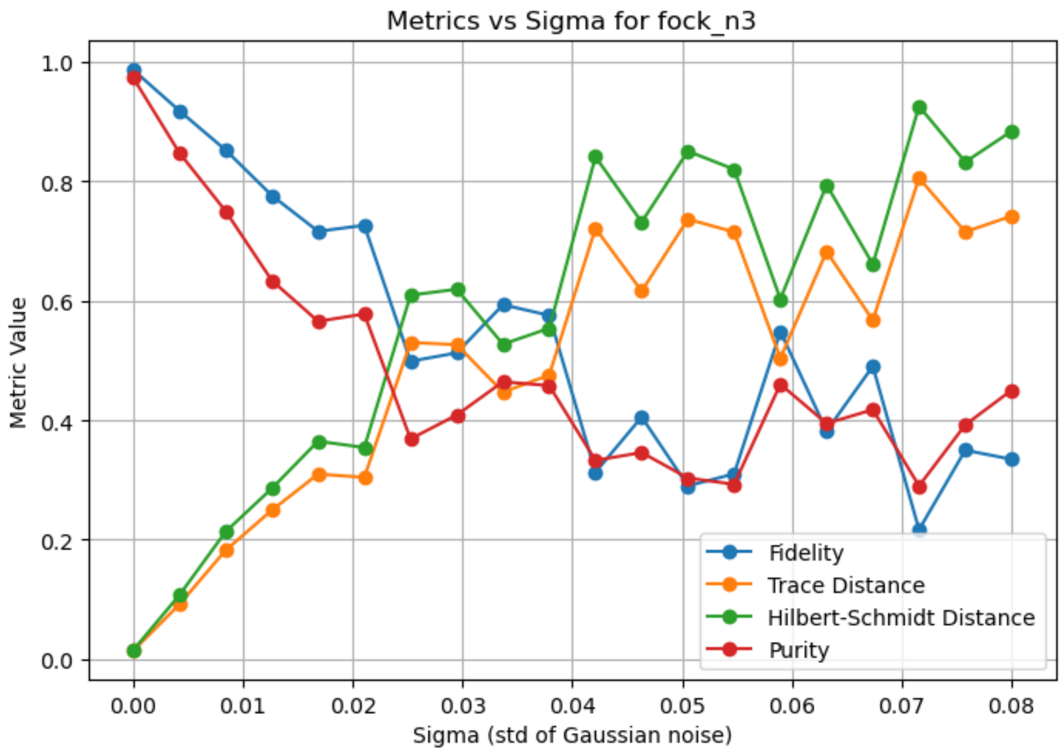


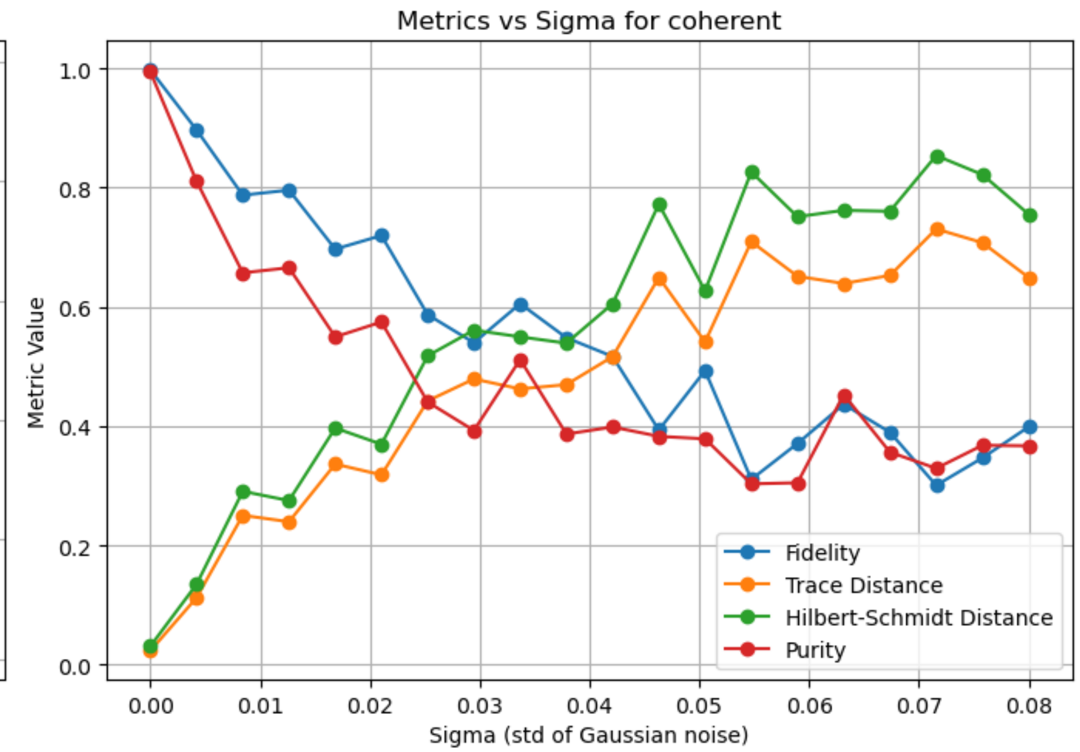
0.013727   0.022967   0.012412   0.033844

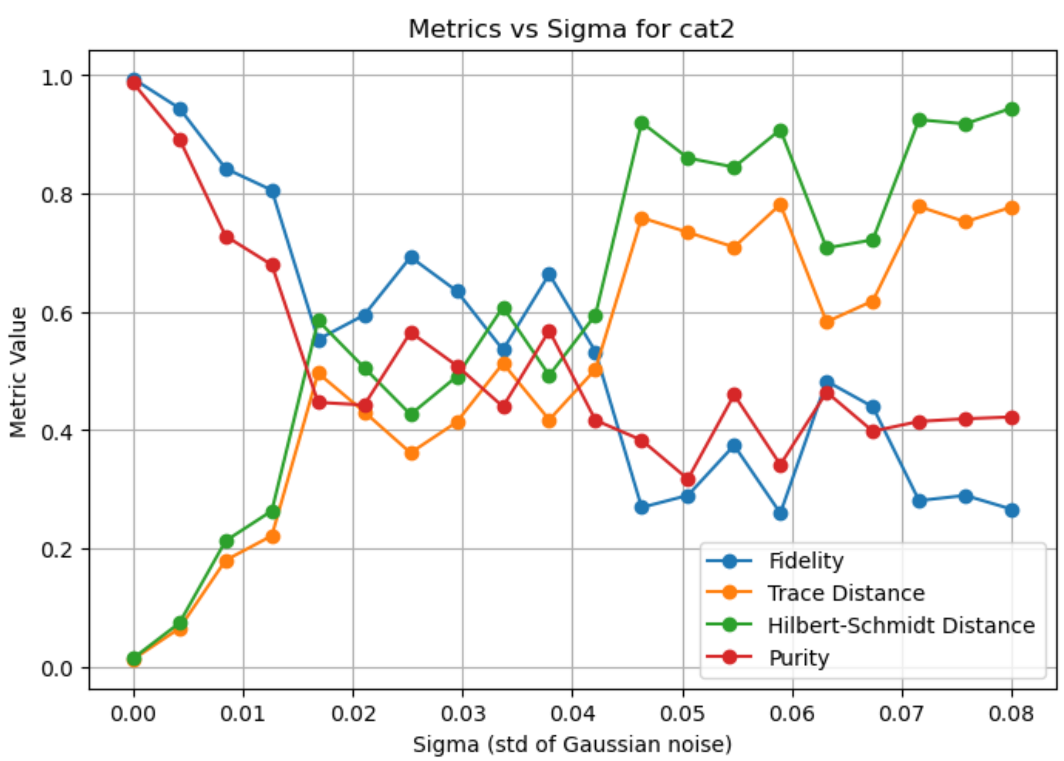
Trace distances

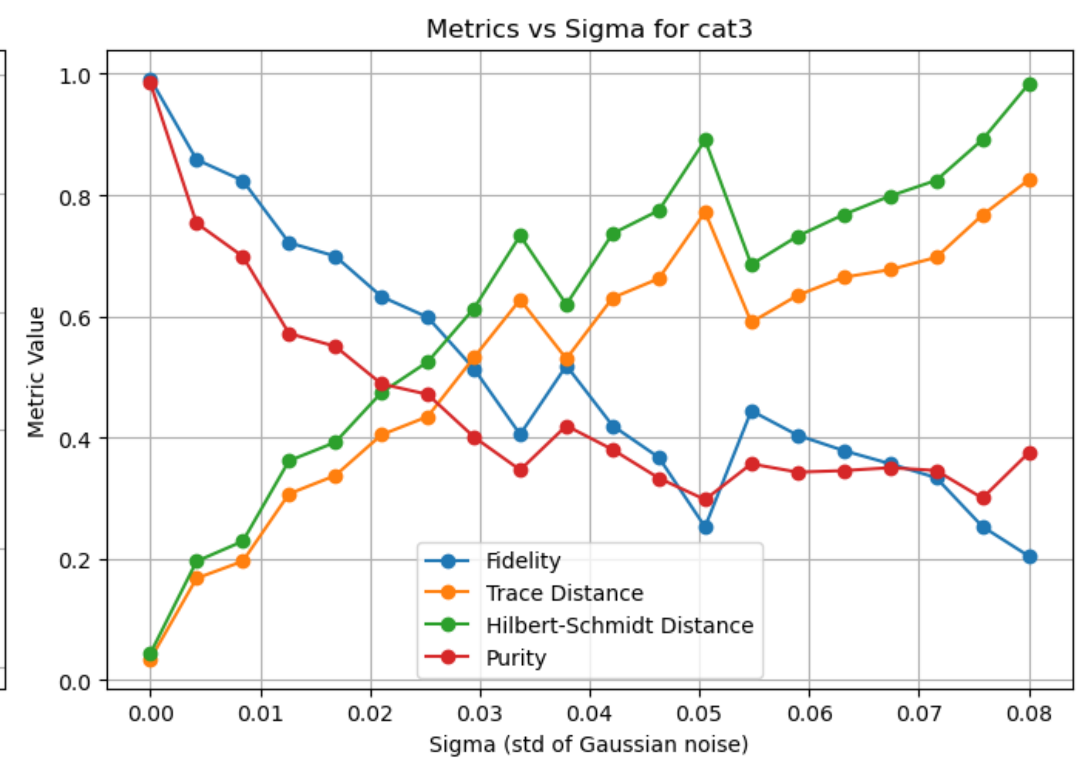
1.C. Robustness of the fit

1.C.1. Gaussian noise

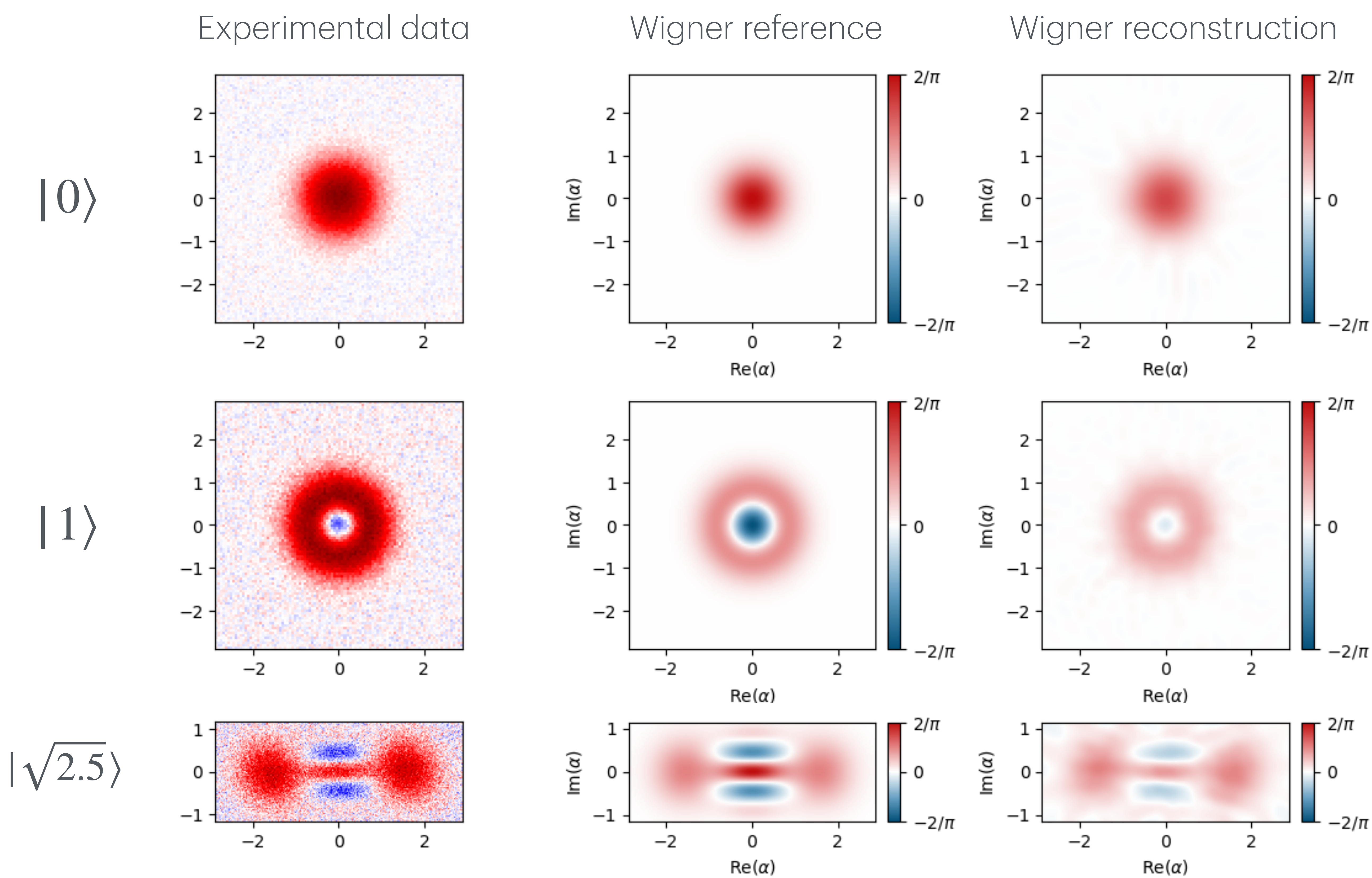




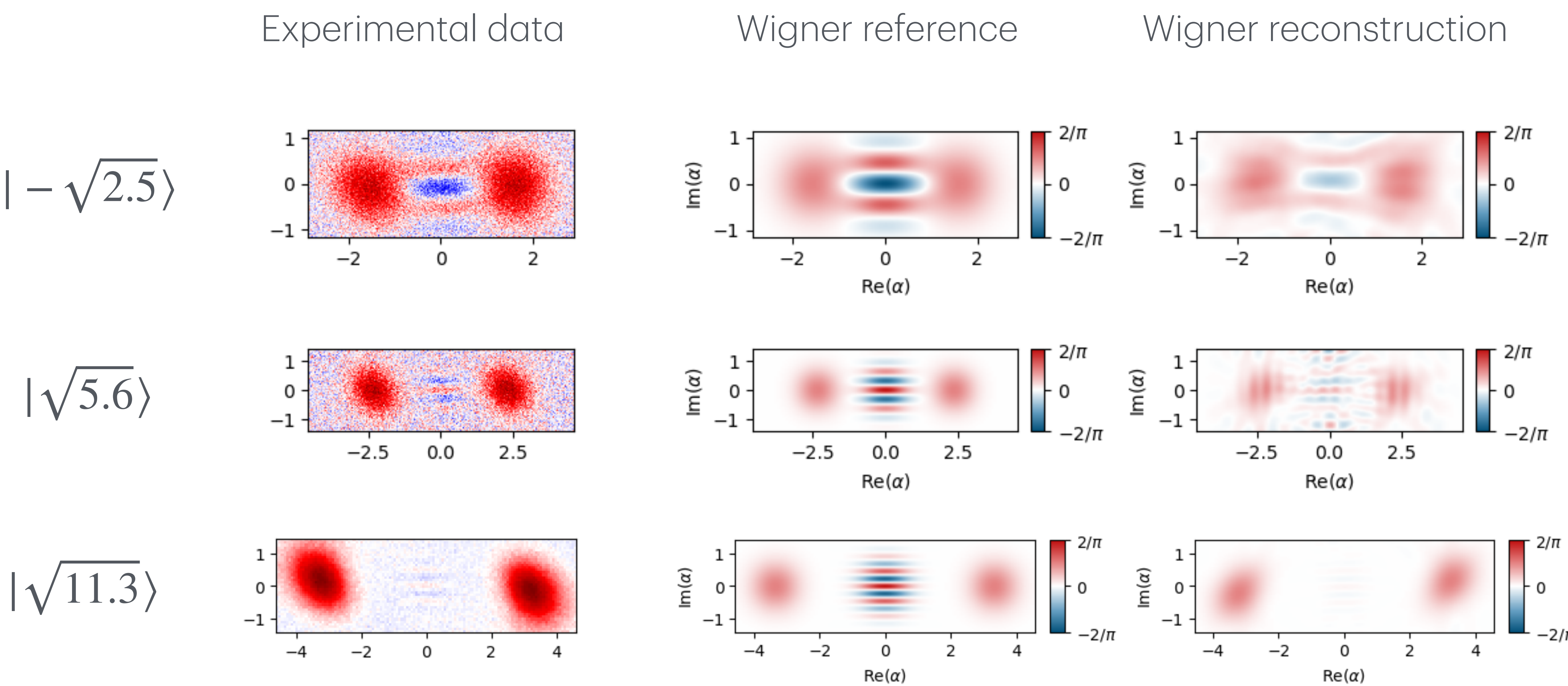




1.C. Robustness of the fit



1.C. Robustness of the fit



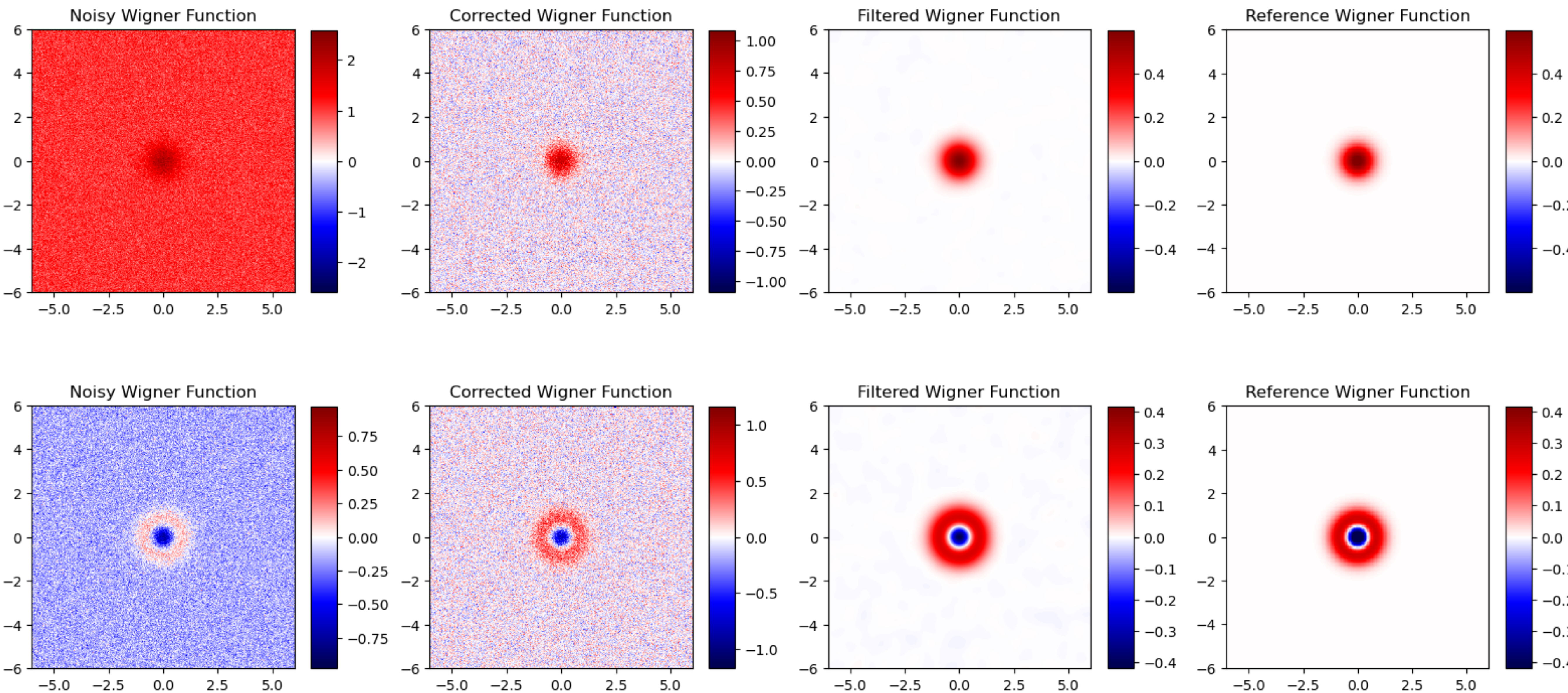
1.C. Robustness of the fit

	Fidelity	Trace distance	Purity
$\vert 0\rangle$	0.868	0.868	0.770
$\vert 1\rangle$	0.519	0.482	0.438
$\vert \sqrt{2.5}\rangle$	0.679	0.352	0.568
$\vert -\sqrt{2.5}\rangle$	0.609	0.422	0.532
$\vert \sqrt{5.6}\rangle$	0.525	0.556	0.533
$\vert \sqrt{11.3}\rangle$	0.487	0.540	0.500

Bonus

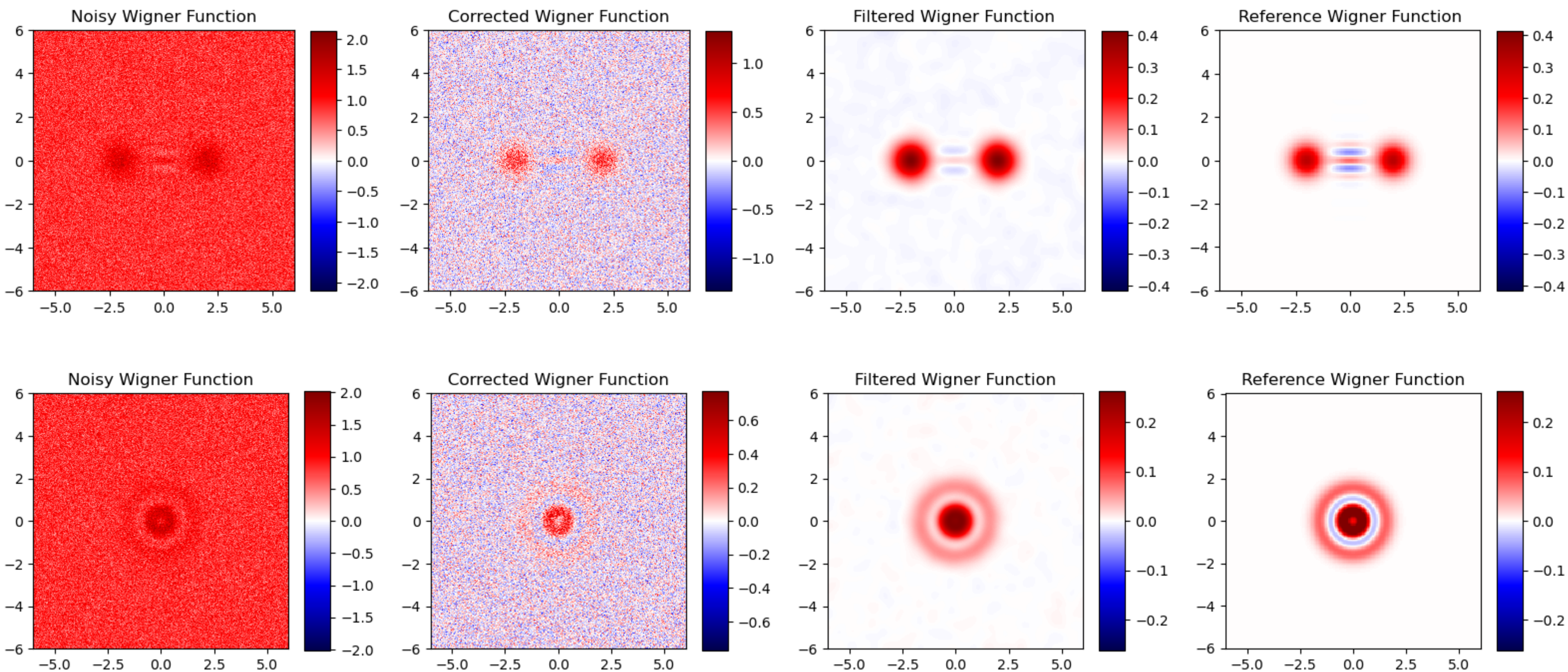
2. Denoising

2.A. Correcting Affine Distortions and Background Noise



2. Denoising

2.A. Correcting Affine Distortions and Background Noise



2. Denoising

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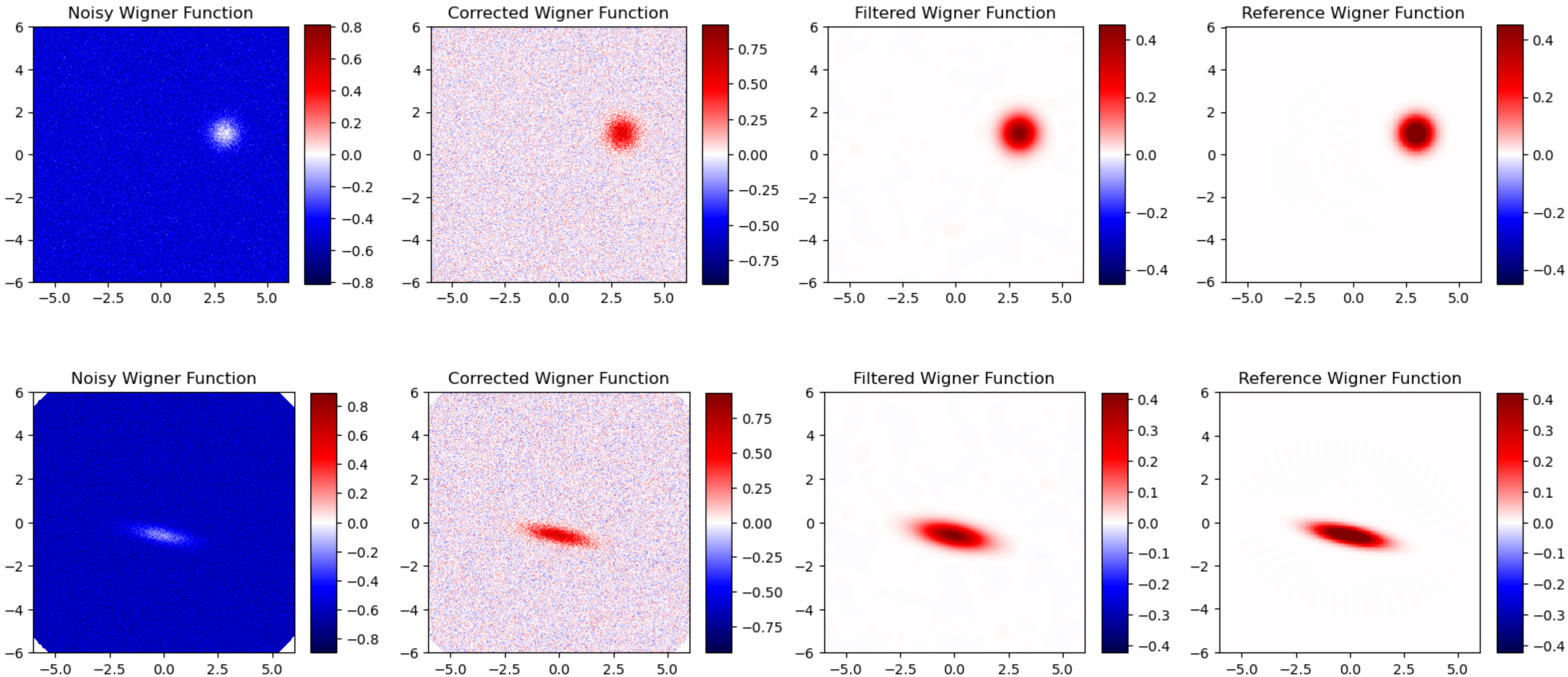
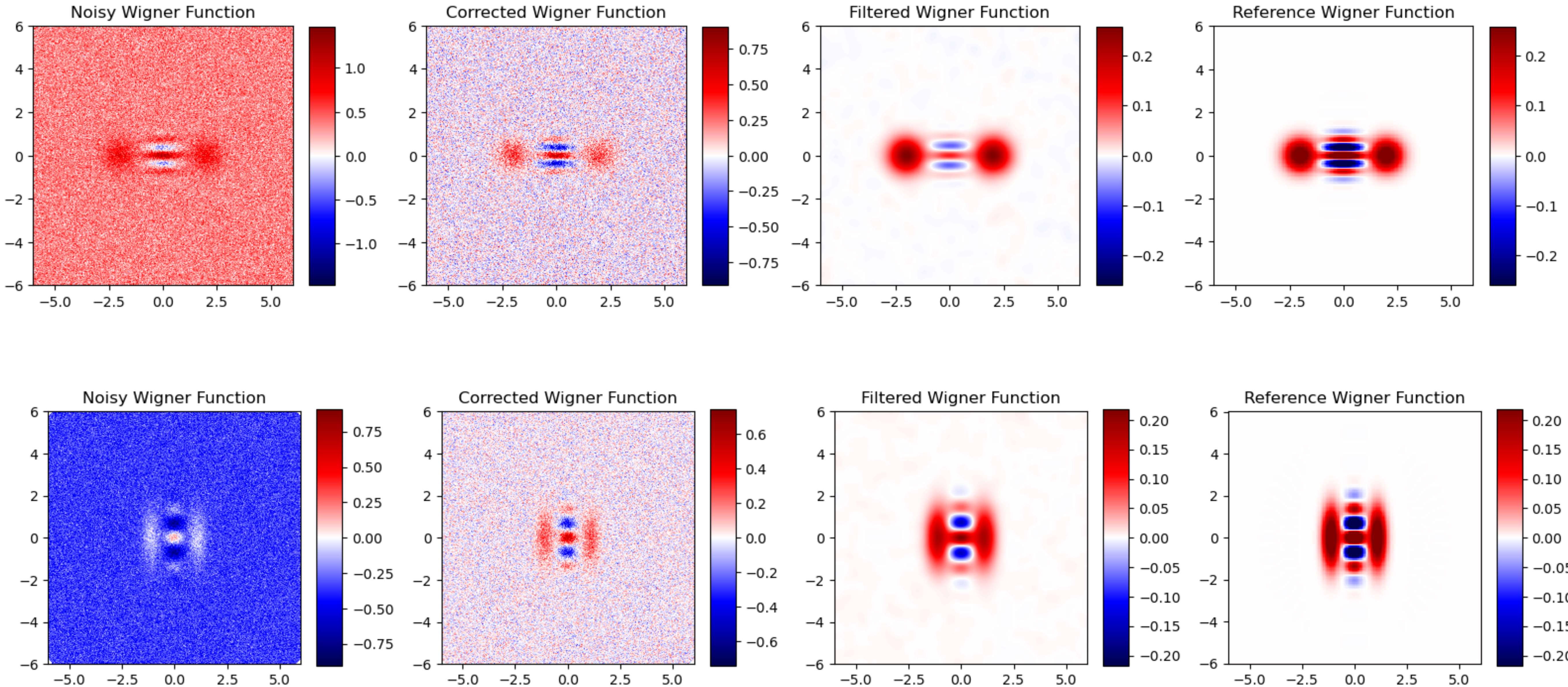


2. Denoising

2.A. Correcting Affine Distortions and Background Noise



2. Denoising

2.A. Correcting Affine Distortions and Background Noise

A filter with $\sigma \approx 20$ tends to work better for all the measurements