A QCNN for Quantum State Preparation

Carnegie Vacation Scholarship

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Week 5
(29/07/2024 - 02/08/2024)

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Aims for the Week

The following aims were set at the last meeting (29/07/2024):

Improve Loss Function

Work on an improved version of WILL. Incorporate some phase extraction metrics (e.g. χ, ϵ) into the loss function.

Investigate Phase Extraction

Study the relationship between mismatch and the extracted phase, i.e. study the operator $\tilde{Q}^{\dagger}(\hat{I} \otimes \hat{R})\tilde{Q}$.

Mitigate Barren Plateaus

Work on strategies to mitigate barren plateaus, e.g. implement layer-by-layer training.

THIS WEEK INCLUDE EXAMPLES WITH HIGH m !!

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WILL Revisited

- As discussed at the meeting on 29/07, the definition of WILL (weighted L_p loss) was amended to:

$$\mathrm{WILL}_{p,q} = \left(\sum_k \left| x_k - y_k \right|^p + |x_k| \left| [k]_m - \Psi([k]_n) \right|^q \right)^{1/p}, \quad (1)$$

  where the changes to the previous definition are highlighted
- Testing this for different Ψ (with $L = 6$, $m = 3$ and 600 epochs) yielded the following optimal values for p, q:

$\Psi(f)$	p	q
$\sim f$	0.25	0.5
$\sim f^2$	1	1.5
Ψ_{H23}	0.75	2

Table 1: Optimal identified p, q values for WILL

Comparing SAM, WIM, and WILL

	SAM	WIM	WILL
μ	**3.4e-2**	6.0e-2	4.5e-1
σ	1.4e-1	1.1e-1	4.7e-1
ϵ	**1.9e-2**	9.2e-2	2.6e-1
χ	**3.2e-2**	5.1e-2	3.7e-1
Ω	**4.46**	3.19	0.76

Table 2: Comparing loss function metrics for $\Psi(f) \sim f$ ($L = 6$, $m = 3$, 600 epochs)

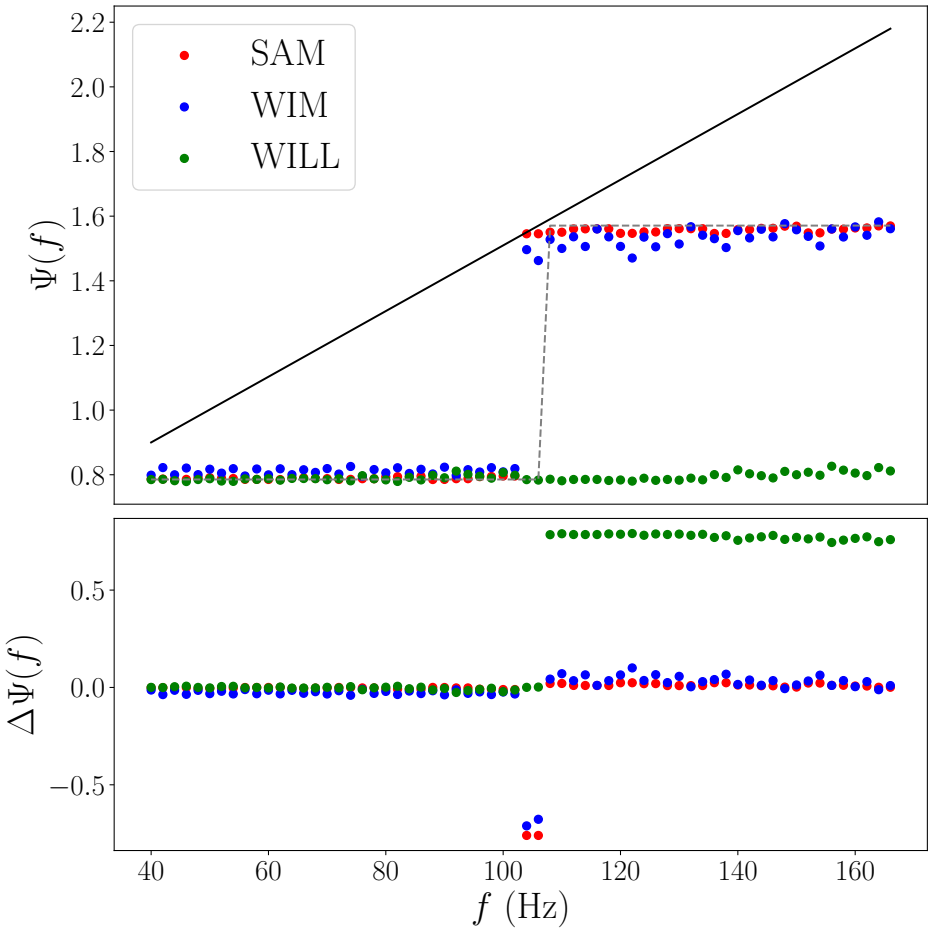

Figure 1: Comparing extracted phase functions for $\Psi(f) \sim f$ ($L = 6$, $m = 3$, 600 epochs)

Comparing SAM, WIM, and WILL

	SAM	WIM	WILL
μ	**1.9e-1**	2.3e-1	6.6e-1
σ	1.2e-1	**1.0e-1**	4.1e-1
ϵ	2.2e-1	4.2e-1	**2.8e-2**
χ	**1.9e-1**	2.0e-1	6.1e-1
Ω	**1.39**	1.05	0.57

Table 3: Comparing loss function metrics for $\Psi(f) \sim f^2$ ($L = 6$, $m = 3$, 600 epochs)

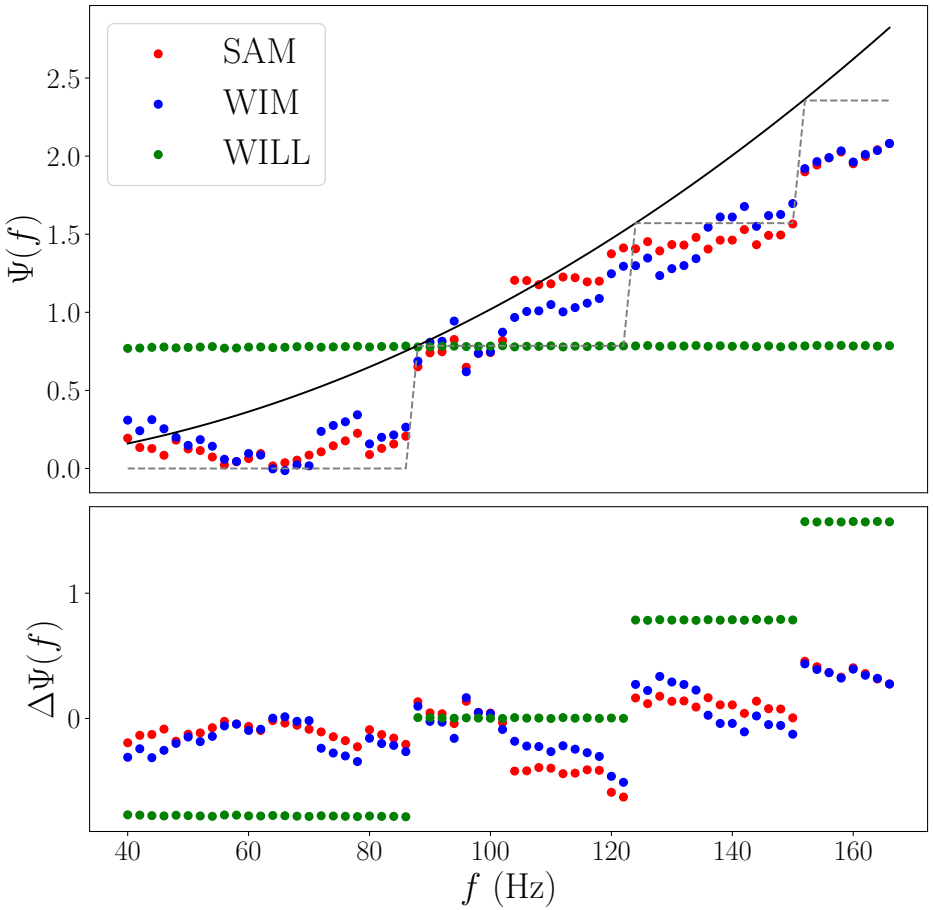

Figure 2: Comparing extracted phase functions for $\Psi(f) \sim f^2$ ($L = 6$, $m = 3$, 600 epochs)

Comparing SAM, WIM, and WILL

	SAM	WIM	WILL
μ	**6.8e-2**	8.4e-2	7.6e-2
σ	1.8e-1	**1.2e-1**	2.6e-1
ϵ	4.5e-2	1.8e-1	**7.3e-3**
χ	7.4e-2	1.0e-1	**6.2e-2**
Ω	**2.75**	2.07	2.48

Table 4: Comparing loss function metrics for Ψ_{H23} ($L = 6$, $m = 3$, 600 epochs)

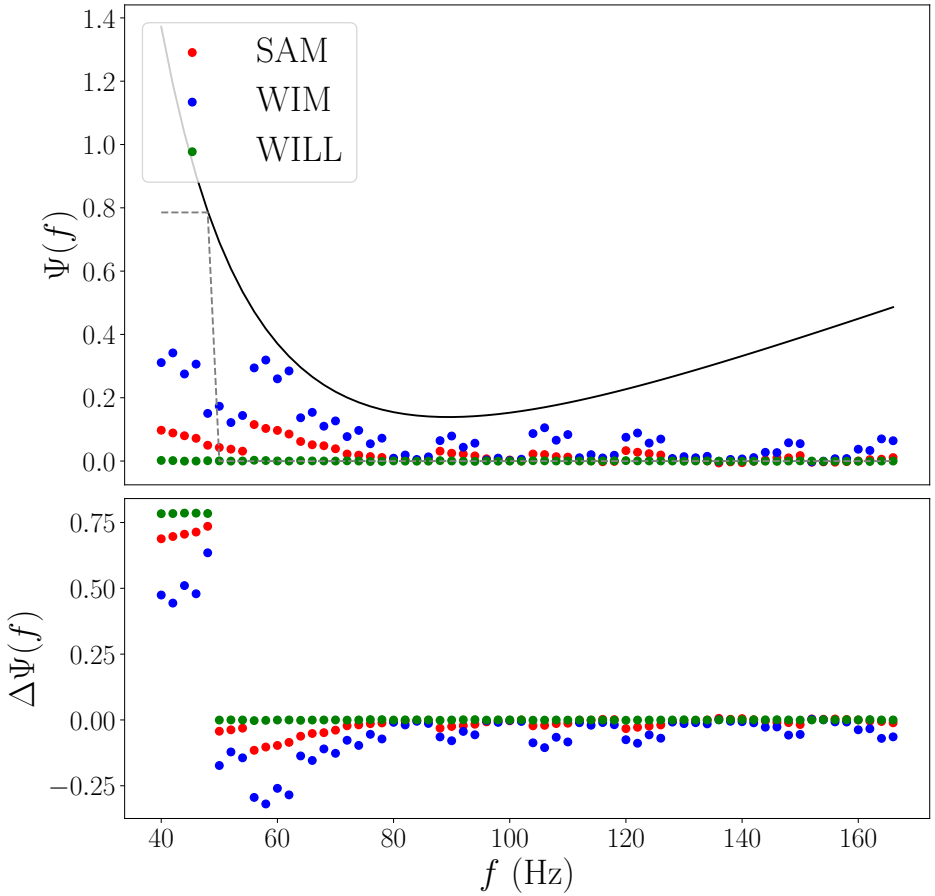

Figure 3: Comparing extracted phase functions for Ψ_{H23} ($L = 6$, $m = 3$, 600 epochs)

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Next Steps

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