Evaluation of gate designs

For trapped ion quantum computers

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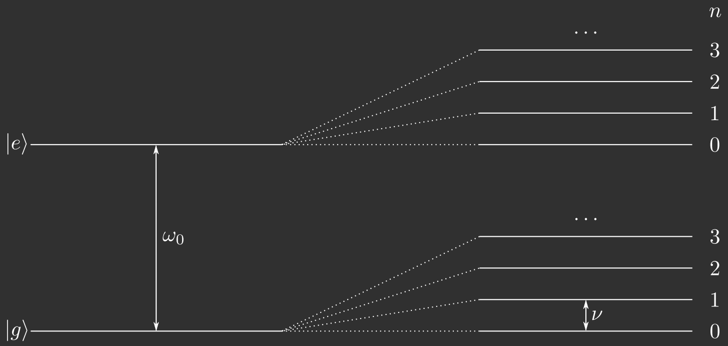
Energy structure



$$\hat{H} = -\frac{\hbar\omega_0}{2}\hat{\sigma}_z + \hbar\nu\left(\hat{a}^\dagger\hat{a} + \frac{1}{2}\right)$$

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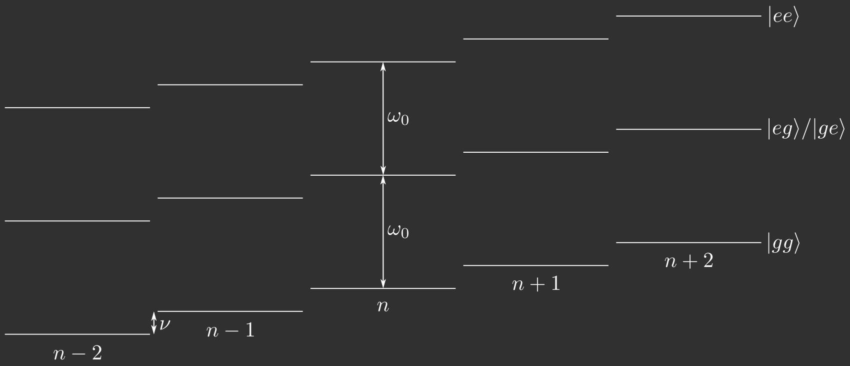

$$\hat{H} = -\frac{\hbar\omega_0}{2}\sum_i^n \hat{\sigma}_z^{(i)} + \hbar\nu\left(\hat{a}^\dagger\hat{a} + \frac{1}{2}\right)$$

Driving the system

$$\hat{H} = -\frac{\hbar\omega_0}{2}\sum_{i}^{n}\hat{\sigma}_z^{(i)} + \hbar\nu\left(\hat{a}^\dagger\hat{a} + \frac{1}{2}\right) + \sum_l \frac{\Omega_l}{2}\hat{\sigma}_+^{(n_l)}e^{-i(\mathbf{kz}-\omega_l t)} + h.c.$$

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$$\eta = \mathbf{kz_0} \qquad \hat{\hat{a}} = \hat{a}e^{-i\nu t} \qquad \hat{\hat{a}}^\dagger = \hat{a}^\dagger e^{i\nu t}$$

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$$\hat{H}_I = \sum_l \frac{\Omega_l}{2}\hat{\sigma}_+^{(n_l)} e^{-i\left(\eta\left(\hat{\tilde{a}}+\hat{\tilde{a}}^\dagger\right)-\Delta_l t\right)} + h.c.$$

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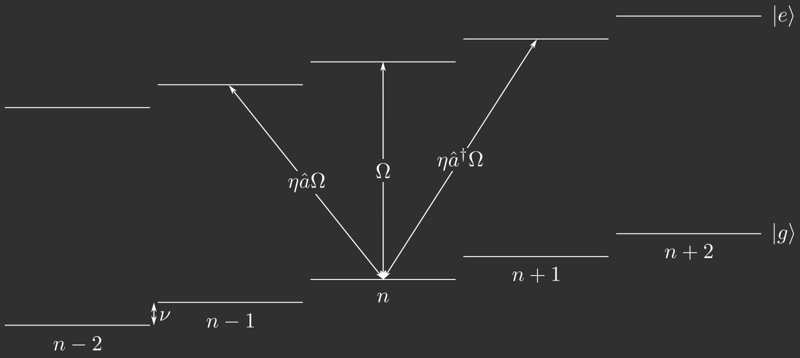
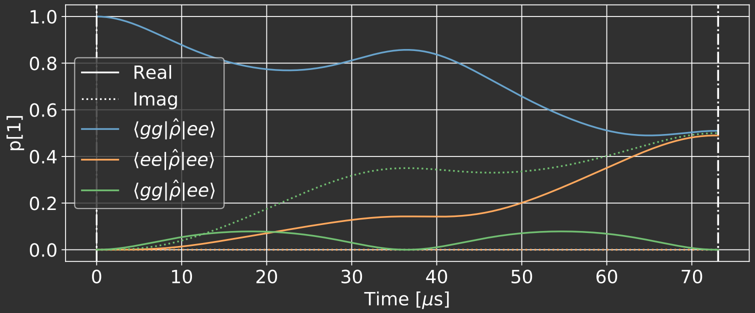
Lamb-Dicke regime



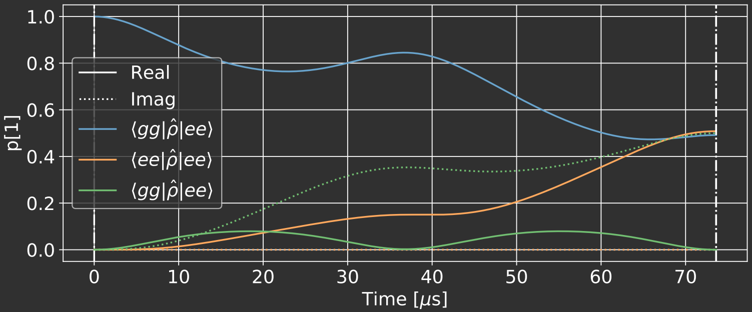
$$e^{i\eta\left(\hat{\hat{a}}+\hat{\hat{a}}^\dagger\right)} \approx \hat{\mathbb{1}} + i\eta\left(\hat{\hat{a}}+\hat{\hat{a}}^\dagger\right) + \mathcal{O}\left(\eta^2\right)$$

Mølmer-Sørensen gate[1]



[1] A. Sørensen and K. Mølmer, "Entanglement and quantum computation with ions in thermal motion,", 2000.

Strong coupling gate[2]



[2] M. Sameti, J. Lishman, and F. Mintert, "Strong-coupling quantum logic of trapped ions," , 2021.

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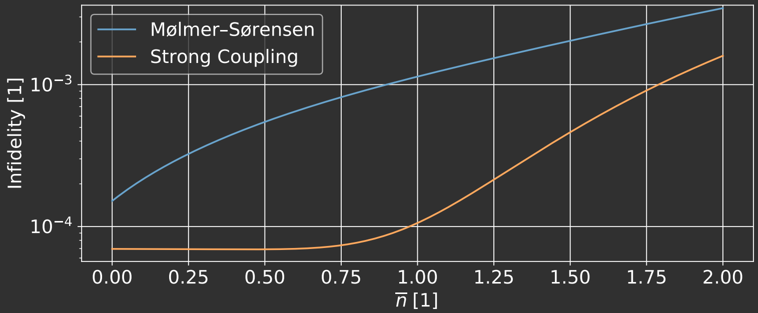

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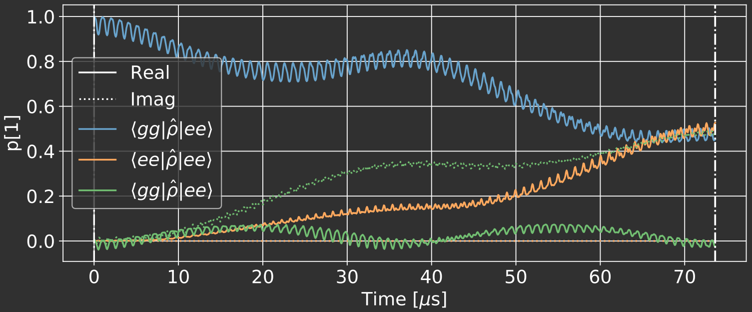

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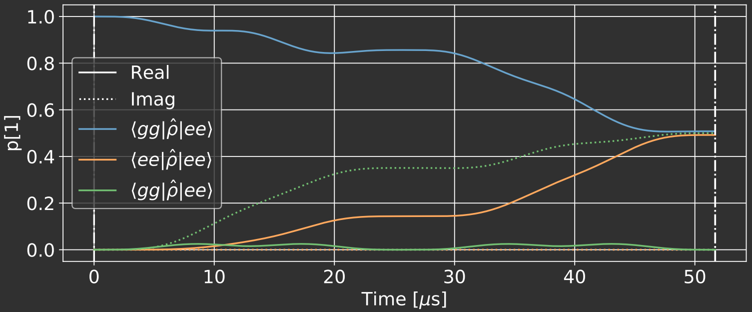
Cardioid gate[3]



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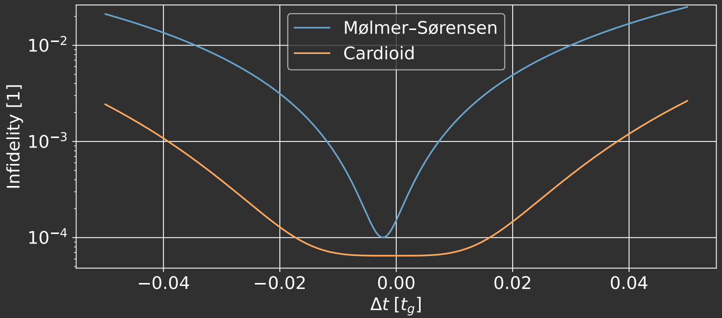

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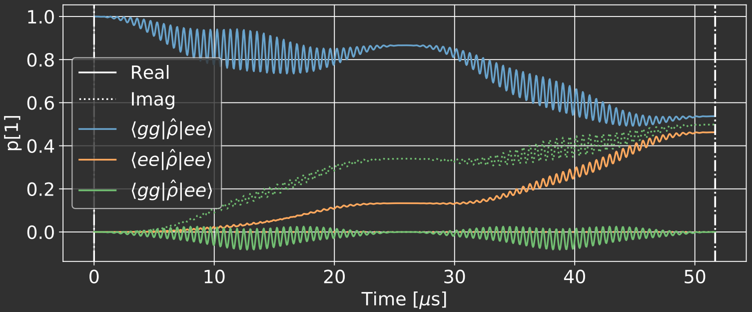

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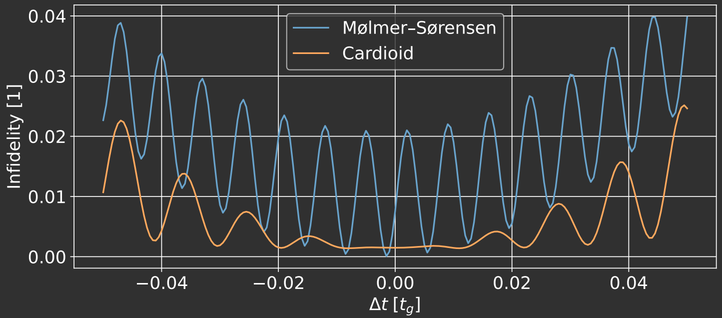

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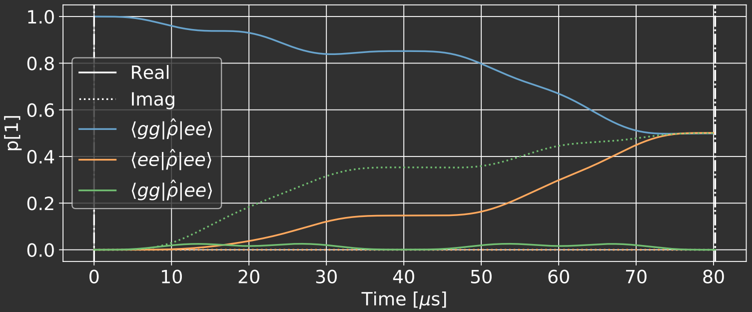
Compound gate



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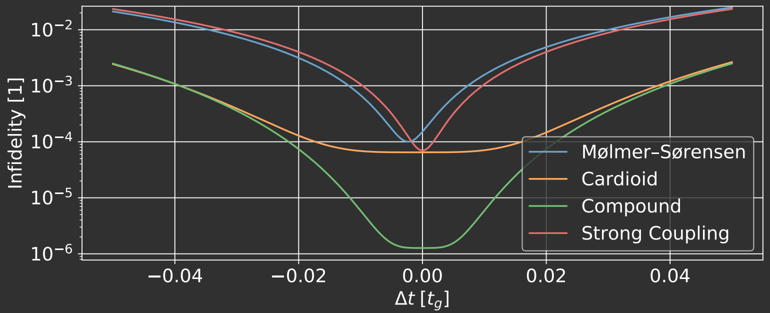

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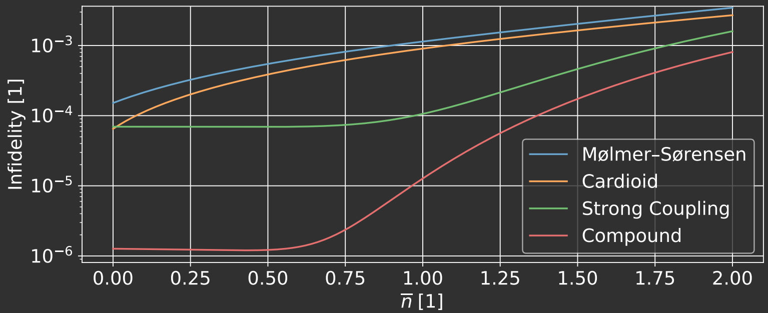

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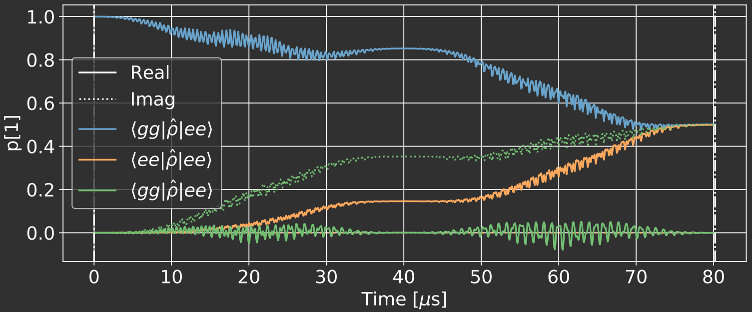

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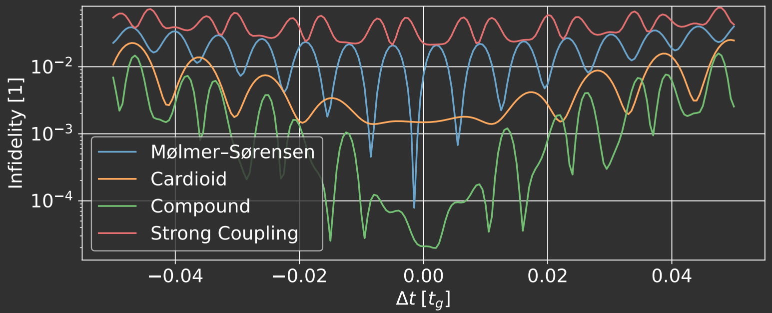

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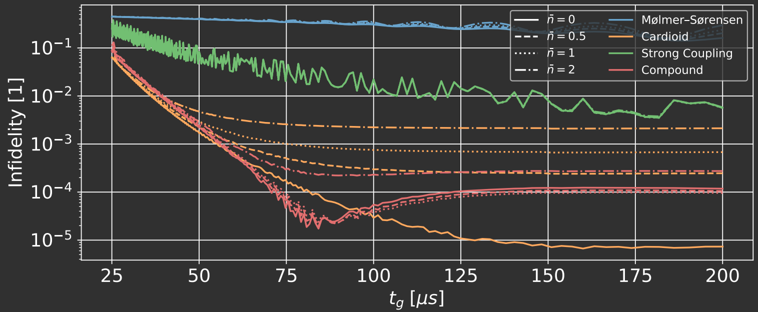

Dynamical decoupling

a

b

Thank you for the attention