

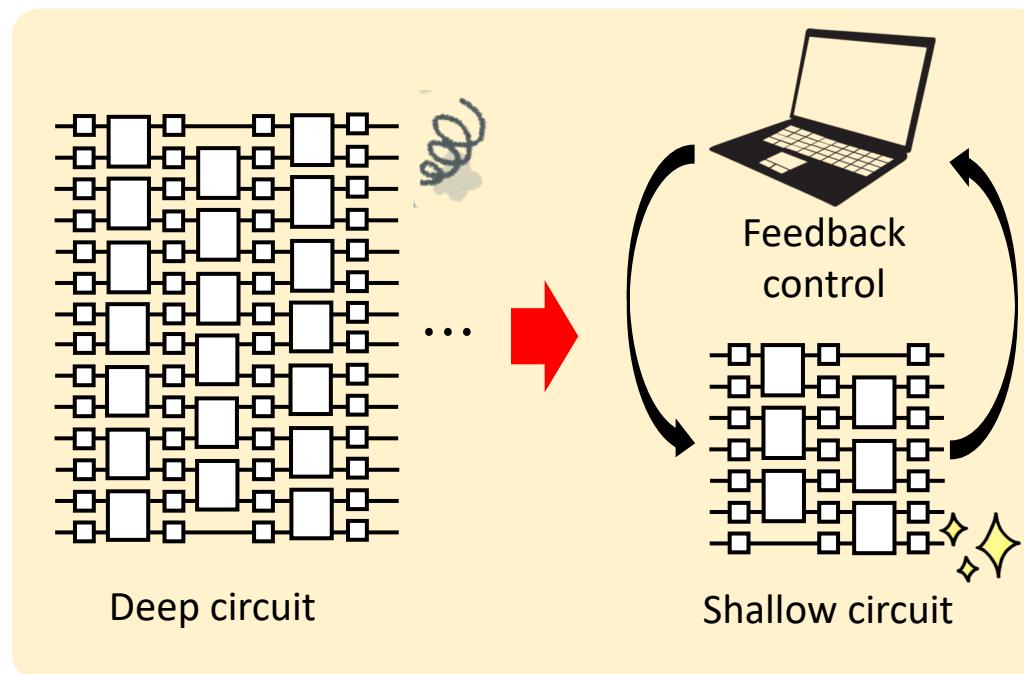


Controlled time evolution on NISQ devices

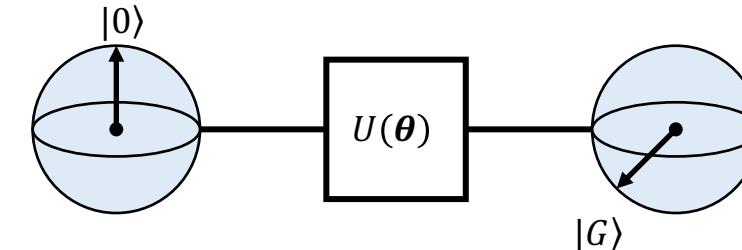
Kentaro Heya, Risa Segawa
IBM coach: Tanut Karnwai, Toshinari Itoko

Quantum computing in Noisy Intermediate Scale Quantum era

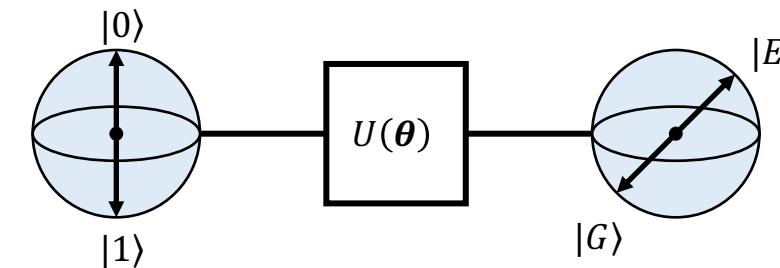
Noisy intermediate scale quantum era [1]



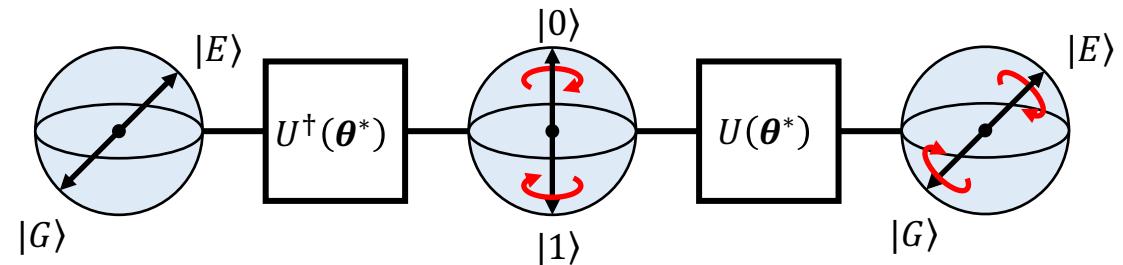
(1) VQE [2] (Finding ground state)



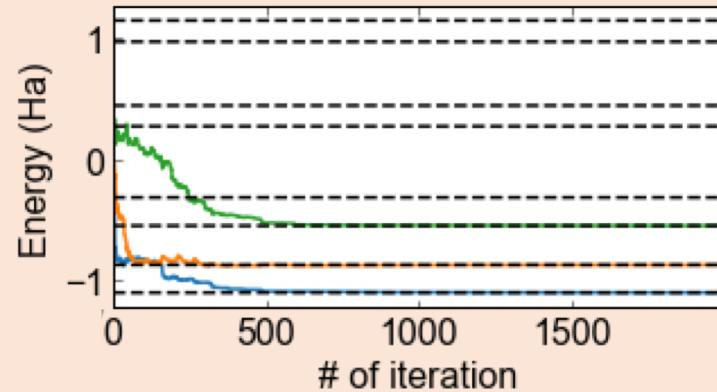
(2) SSVQE [3] (Finding excited states)



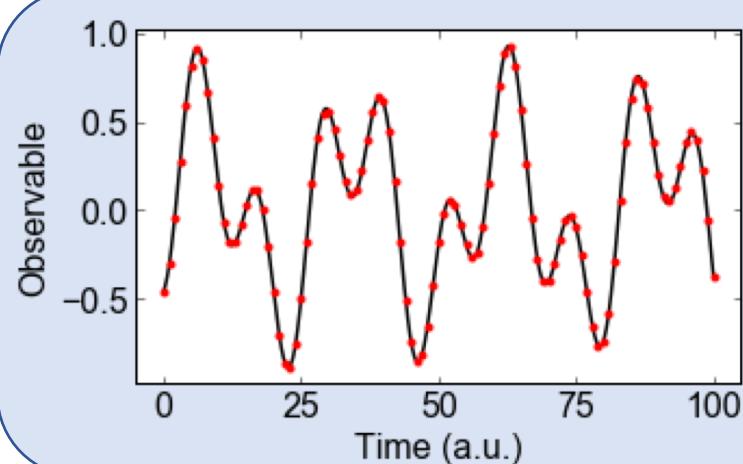
(3) SVQS [4] (Simulating time evolution)



Implement SSVQE & SVQS on Qiskit

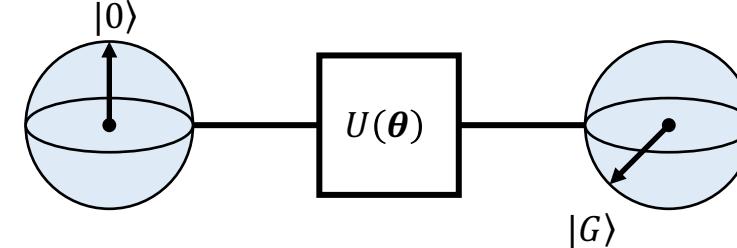


— SSVQE(E_0)
— SSVQE(E_1)
— SSVQE(E_2)
- - - Energy levels

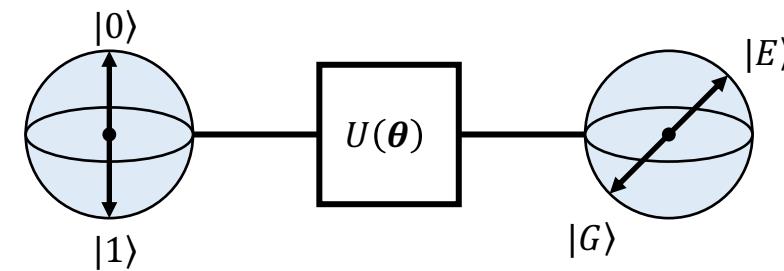


— Theory
• SVQS

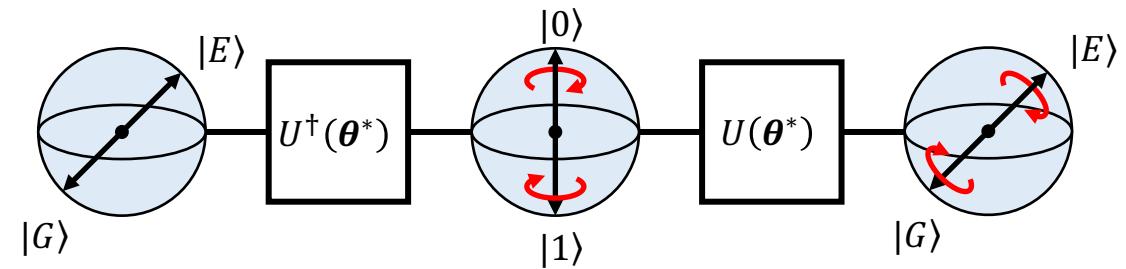
(1) VQE [2,3] (Finding ground state)



(2) SSVQE [4] (Finding excited states)



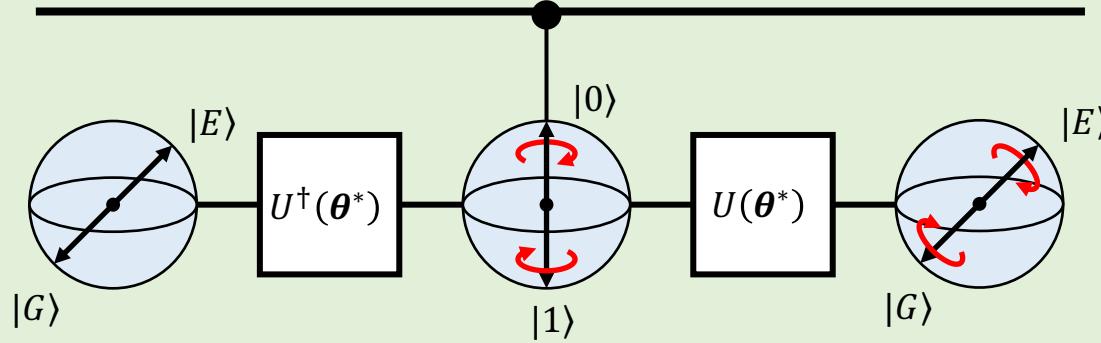
(3) SVQS [5] (Simulating time evolution)



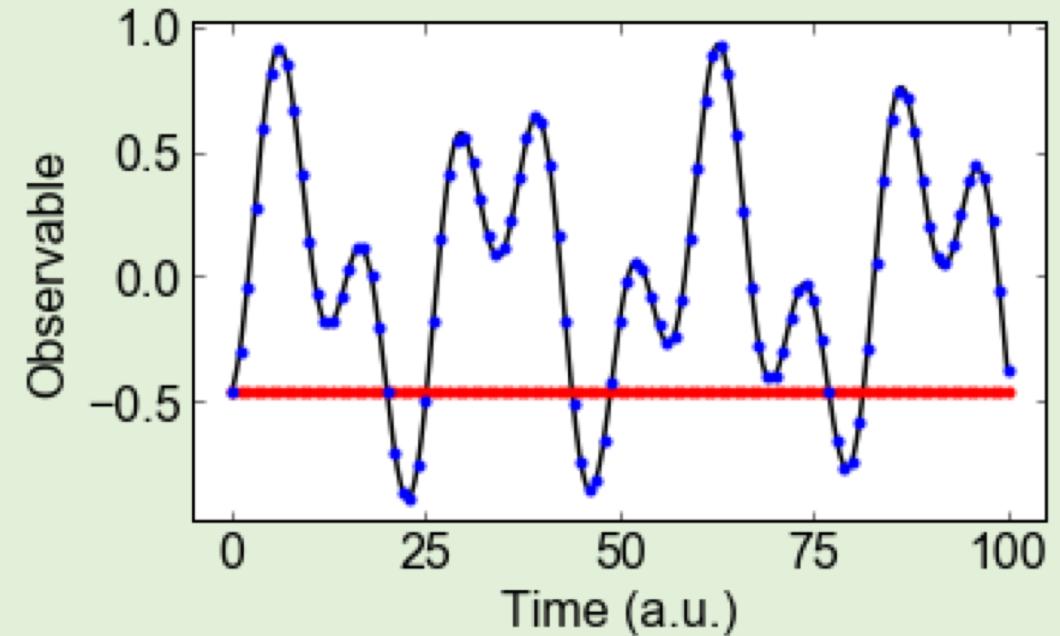
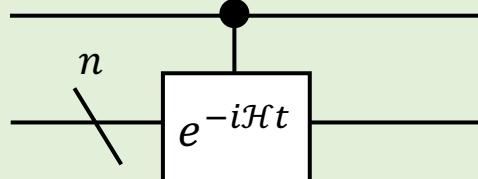
Propose and implement controlled-SVQS on Qiskit

CSVQS

: for simulating controlled time evolution



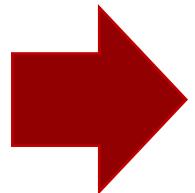
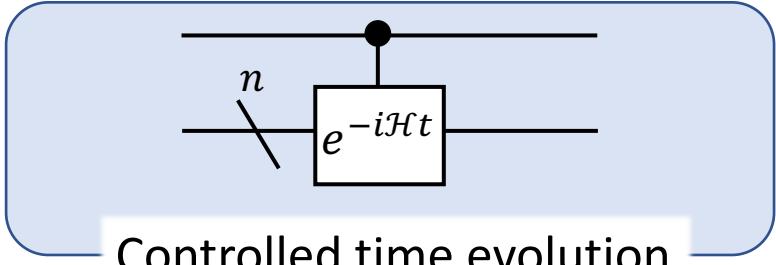
||



- Theory
- CSVQS ancilla 0
- CSVQS ancilla 1

Future prospection

① Application



Loshmit echo

$$\langle \varphi | e^{-i\mathcal{H}t} | \varphi \rangle$$

Generalized Green function

$$\langle G | e^{i\mathcal{H}t} A e^{-i\mathcal{H}t} B | G \rangle$$

Out of time order correlation

$$\langle W(t)V(0)W(t)V(0) \rangle_\beta$$

② Tolerance

Check tolerance for ...

- small number sampling
- noisy environment

③ Considering...



Qiskit Aqua

Algorithms for near-term quantum applications

References

- [1] J.Preskill, Quantum 2, 79 (2018).
- [2] A. Peruzzo, Nat. Commun. 5, 4213 (2014).
- [3] K. M. Nakanishi, *et al*, Phys. Rev. Research 1, 033062 (2019).
- [4] K. Heya, *et al*, arXiv:1904.08566 (2019).

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