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Simple many-body dynamics is a powerful quantum reservoir

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Many body quantum systems internally have exponentially huge Hilbert spaces and complex dynamics. Much research has been done to find ways to exploit this complexity for practical applications and information processing. Quantum reservoir computing has garnered attention as an approach to directly utilize the complexity of quantum dynamics as a computational resource[1,2]. It is considered for potential applications with Noise-Intermediate Scale Quantum (NISQ) devices. Several studies have reported that complex dynamics possess enough complexity to serve as effective reservoirs. On the contrary, can simple quantum systems be used as reservoirs? For example, can quantum systems, which classical computers can efficiently simulate, work well as reservoirs? This talk will discuss how simple a system can be used as a quantum reservoir and where it cannot be. Furthermore, we discuss the boundary between potent and poor reservoirs[3].
[1] Fujii, Keisuke, et al. “Harnessing disordered-ensemble quantum dynamics for machine learning.” Phys. Rev. Applied 8 024030 (2017).
[2] A. Sakurai et al., “Quantum Extreme Reservoir Computation Utilizing Scale-Free Networks,” Phys. Rev. Applied 17, 064044 (2022).
[3] Sakurai, Akitada, et al. “Simple Hamiltonian dynamics is a powerful quantum processing resource.” arXiv preprint arXiv:2405.14245 (2024).

Primary author(s) : SAKURAI, Akitada (OIST); Mr HAYASHI, Aoi (SOKENDAI); Prof. MUNRO, William (OIST); Prof. NEMOTO, Kae (OIST)

Presenter(s) : SAKURAI, Akitada (OIST)

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