Universal Control Induced by Noise

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Very frequent measurement on a quantum system projects the system onto the subspaces in the Hilbert space specified by the measurement, and the dynamics of the system is confined within the subspaces, evolving unitarily there. This is known as the quantum Zeno effect (QZE), and the unitary dynamics within the subspaces (Zeno subspaces) is called the quantum Zeno dynamics (QZD).

In this talk, we provide another interesting effect of the QZE: the QZE can *exponentially* enrich the dynamics of a quantum system, so as for us to be able to perform universal quantum computation. Suppose that we are given two Hamiltonians which are commutative with each other. Even if we switch on and off the two Hamiltonians, we can realize only trivial dynamics, due to the commutativity. We can change the situation by the QZE: if we frequently measure a small part of the system to induce the QZD, the two Hamiltonians are projected by the frequent measurement and become noncommutative with each other. Moreover, the two projected Hamiltonians are enough to realize any unitary evolution within the Zeno subspaces. In other words, we are able to perform universal quantum computation within the Zeno subspaces. We prove that this effect is generally to be expected: almost any quantum dynamics becomes universal if it is observed very frequently.

The same effect can be induced by strong dissipative and/or dephasing process. In particular, it can turn trivial control into universal one, at the same time realizing decoherence-free subspaces. We can also do the opposite: any complex quantum dynamics can be viewed as a projected dynamics of a trivial dynamics in an extended Hilbert space. The Hamiltonians can be "purified" to make them commutative in larger dimensions.

This talk is based on the works published in Refs. [1-3], in collaboration with C. Arenz, D. Burgarth, P. Facchi, V. Giovannetti, H. Nakazato, D. Orsucci, and S. Pascazio.

References

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[3] C. Arenz, D. Burgarth, P. Facchi, V. Giovannetti, H. Nakazato, S. Pascazio, and K. Yuasa, *Universal Control Induced by Noise*, Phys. Rev. A **93**, 062308 (2016).