Due to great development on experimental technologies, it is possible to capture quantum dynamics in some physical and chemical systems. On the other hand, all experiments are in principle open and dissipative systems. Up to now, the well explained experiments are approximated to the equilibrium situation. However, by recent technological development, some experiments reach to a transition from equilibrium to non-equilibrium situations. While there are the well-known tools on the non-equilibrium situations; the linear response theory and the Keldysh Green function method, this analysis cannot basically catch dynamical situations. Our goal is to construct the time-resolved theoretical models included the non-equilibrium situations. However, the quantum measurement theory is needed on measuring quantum dynamics, especially considering the measurement back action. Our current activities are to resolve how sensitive (quantum) measurement can we carry out in principle, to build up some toy models on quantum dynamic and to explain unique quantum-mechanical phenomena using precise quantum-state engineering technology.

**Selected Publications**

1. Quantum Measurement with Higher Order Gaussian Modes

We propose a stereographical-visualization scheme for a polarization state by two-dimensional imaging of a weak value with a single setup. The key idea is to employ Laguerre Gaussian modes or an optical vortex beam for a probe state in weak measurement. Our scheme has the advantage that we can extract information on the polarization state from the single image in which the zero-intensity point of the optical vortex beam corresponds to a stereographic projection point of the Poincaré sphere. We experimentally perform single-setup weak measurement to validate the stereographical relationship between the polarization state on the Poincaré sphere and the location of the zero-intensity point.

2. Quantum Measurement Sensitivity without Squeezing Technique

The weak measurement was proposed in the context of the time-symmetric quantum measurement without collapsing the quantum state. The weak value as the measurement outcome of the weak measurement can exceed the eigenvalue. By this fact, the signal can be amplified. This is called the weak-value amplification. To study the invisible region under the standard technique, there are several studies on the weak-value amplification. Here, the following question arises. How can the signal maximize? To solve this problem, the probe wave function should be changed from the Gaussian distribution, which is originally used. We show the probe wave function to maximize the shift while this mode is not the propagation mode in light.

3. Discrete Time Quantum Walk as Quantum Dynamical Simulator

Constructing a discrete model like a cellular automaton is a powerful method for understanding various dynamical systems. However, the relationship between the discrete model and its continuous analogue is, in general, nontrivial. As a quantum mechanical cellular automaton, a discrete-time quantum walk is defined to include various quantum dynamical behavior. Here we generalize a discrete-time quantum walk on a line into the feed-forward quantum coin model, which depends on the coin state of the previous step. We show that our proposed model has an anomalous slow diffusion characterized by the porous-medium equation, while the conventional discrete-time quantum walk model shows ballistic transport.

References

Awards
SHIKANO, Yutaka; FQXi (Foundational Questions Institute) Essay Contest “It from Bit or Bit from It” Fourth Prize. (2013)
SHIKANO, Yutaka; 2013 Quantum Information Processing Top Reviewers.
SHIKANO, Yutaka; Research Foundation for Opto-Science and Technology Research Award (2014).

* IMS International Internship Program from Koc University, Turkey
† IMS International Internship Program from Institute for Theoretical Physics, Chinese Academy of China, China
‡ JSPS Summer Internship Program from University Pierre and Marie Curie, France
§ Asia Bound Program from University of Western Australia, Australia
¶ Asia Bound Program from University of Western Australia, Australia
|| Asia Bound Program from University of Science and Technology of China, China
‡‡ from Hokkaido University
** from University of Science and Technology of China, China
†† from Nara Woman University