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Generation and detection of itinerant microwave photons using a superconducting qubit

*Shingo Kono[1], Kazuki Koshino[2], Jesper Ilves[3], Yoshiki Sunada[3], Yutaka Tabuchi[3], Atsushi Noguchi[3], Yasunobu Nakamura[1,3]

Center for Emergent Matter Science (CEMS), RIKEN[1]
College of Liberal Arts and Sciences, Tokyo Medical and Dental University[2]
Research Center for Advanced Science and Technology (RCAST), The University of Tokyo[3]

A quantum network based on itinerant microwave photons is an indispensable tool to make it easier to implement a large-scale quantum computer with superconducting qubits [1]. In this talk, we show the experimental results on the generation and detection of itinerant microwave photons by using a circuit quantum electrodynamical system, where a microwave cavity plays a crucial role in facilitating the interaction between itinerant microwave photons and a superconducting qubit [2].

First, by utilizing a microwave-assisted interaction between a superconducting qubit and a cavity mode, we generated a single-photon state in a propagating mode [3]. Moreover, we extended the generation scheme to a time-bin photonic qubit, a superposition of a single photon in two orthogonal temporal modes, which can be robust for the propagation loss. Second, we implemented a deterministic entangling gate between a superconducting qubit and an itinerant microwave photon reflected by a cavity containing the qubit. Using the entanglement and high-fidelity qubit readout, we demonstrated a quantum non-demolition detection of a single photon, a photon detection without absorbing the photon energy [4].

These results on itinerant microwave photons can be a building block for the quantum network connecting distant qubit modules. Furthermore, the generation and detection of a quantum state of itinerant microwave field have promising applications for quantum sensing and metrology in the microwave regime [5].

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