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Manipulation of electron waves and solid-state flying qubits

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Varieties of solid-state quantum bits have been investigated, among which the most prominent are superconducting quantum circuits and semiconductor quantum dots. All of them are defined as "localized"quantum two-level systems. Benefits of using such localized systems are isolation of qubits from their environment and potential ability to control individual qubits and inter-qubit coupling with high fidelity. On the other hand, it has been revealed that quantum error correction requires numerous physical qubits to construct a protected logic qubit. For localized systems, one needs hardware for all localized physical qubits being operated continuously to keep protection from errors. In contrast, delocalized quantum two-level systems offer a completely different architecture. In photonic qubits, qubits are created on-demand. The number of qubits is not determined by the hardware size. Manipulation of electron waves allows us to construct electrically tunable delocalized qubits in scalable solid-state systems, where qubits are created on-demand by short voltage pulses. Manipulation of electron waves can also be used to solve problems in condensed matter physics in terms of the quantum interference and phase measurement.

In this talk, we present our projects on manipulation of electron waves. We also apply it on the Kondo physics, demonstrating the most fundamental properties of the Kondo state, the pi/2 phase shift and spatial extension of a Kondo cloud.

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