**Controlling Superconducting Qubits : The Role of Nonadiabatic Transitions**

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Fast and accurate quantum gate controls are desired to develop quantum computers for practical use. Many conventional gate operations exploit external electromagnetic waves to induce resonance transitions. It should be noted that such operations can only be achieved after many cycles of oscillations. On the other hand, there are quantum controls for gate operations that do not use electromagnetic waves, which we expect to be achieved faster than methods using resonance transitions. For some quantum systems, there are controllable parameters in the system's Hamiltonian; for example, in superconducting qubit systems such as fluxonium, the external flux 𝜙ext , is controllable. The time variance of these parameters can induce quantum transitions, meaning that by designing 𝜙ext(𝑡), we can achieve quantum control. However, in order to control the qubits efficiently and precisely, the way we tune the parameter is important.

We take the fluxonium qubit system as an example and propose some quantum controls. In this talk, we will introduce the basic idea of how to design 𝜙ext(𝑡) , and show two applications: X-gate operation and initialization.