Basic Research

20-qubit Schrödinger Cat States with Superconducting Quantum Processor

A joint team of scientists, led by Prof. WANG Haohua from Zhejiang University and Profs. FAN Heng and ZHENG Dongning from the Institute of Physics, Chinese Academy of Sciences (CAS), successfully created Schrödinger cat states of up to 20-qubits with a superconducting quantum processor. In addition, they demonstrated that the generated 18-qubit Greenberger-Horne-Zeilinger (GHZ) state is genuinely entangled. This marks the largest GHZ state ever created in solid state quantum computation platforms so far, and is thought to be a big step toward building a quantum computer.

The superconducting qubit based on Josephson junction is one of the most promising schemes to build a quantum computer, because of its long coherence time, high fidelity control and precise readout. In particular, its potential to integrate a great number of qubits offers an advantageable scalability for the prospective superconducting quantum processor.

To coherently control all qubits in a superconducting quantum processor, it is necessary to ensure that each qubit can be controlled precisely, and any pair of qubits can be entangled. It may be more challenging to show that all qubits can be entangled to generate a GHZ state and Schrödinger cat states. The generation of multiqubit entanglement is a benchmark for demonstrating the performance of quantum devices and the control. To achieve those goals, the scientists from China designed

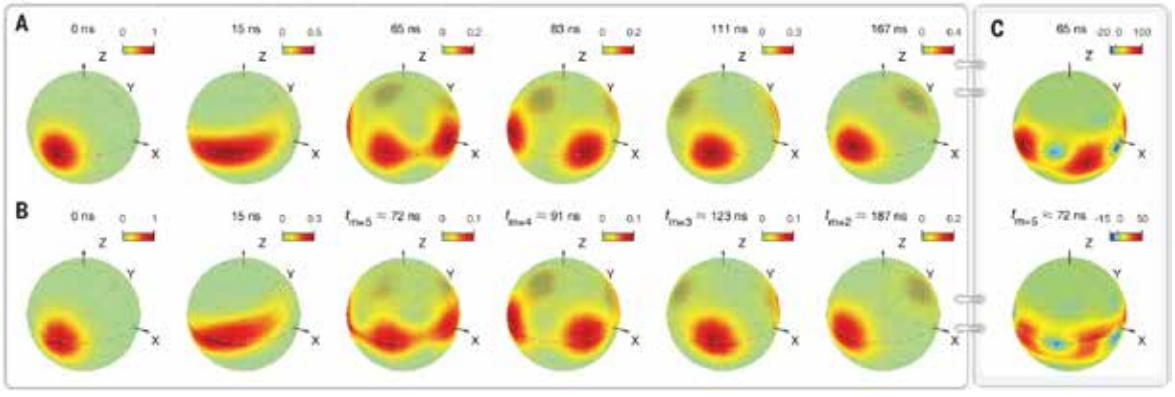

Figure 1: Time evolution of the multiqubit state by numerical simulation and experiment. The Schrödinger cat states in different forms including the GHZ state are created at specific time intervals. [Figure from *Science* 365, 574–577 (2019)]

an all-to-all device with all qubits connected with others. Altogether, the team integrated 20 qubits into the superconducting quantum device, and demonstrated that all of them had long coherence time and could be controlled and readout with high fidelity.

In the experiment, the system of qubits initialized coherently, and evolved to multi-component atomic Schrödinger cat states, *i.e.*, superpositions of atomic coherent states, including GHZ state, at specific time intervals. The fidelity of the generated 18-qubit GHZ state was larger than the threshold to demonstrate the state is genuine multiqubit entanglement.

This study, entitled "Generation of multi-component atomic Schrödinger cat states of up to 20 qubits", was published on *Science* 365, 574–577 (2019).

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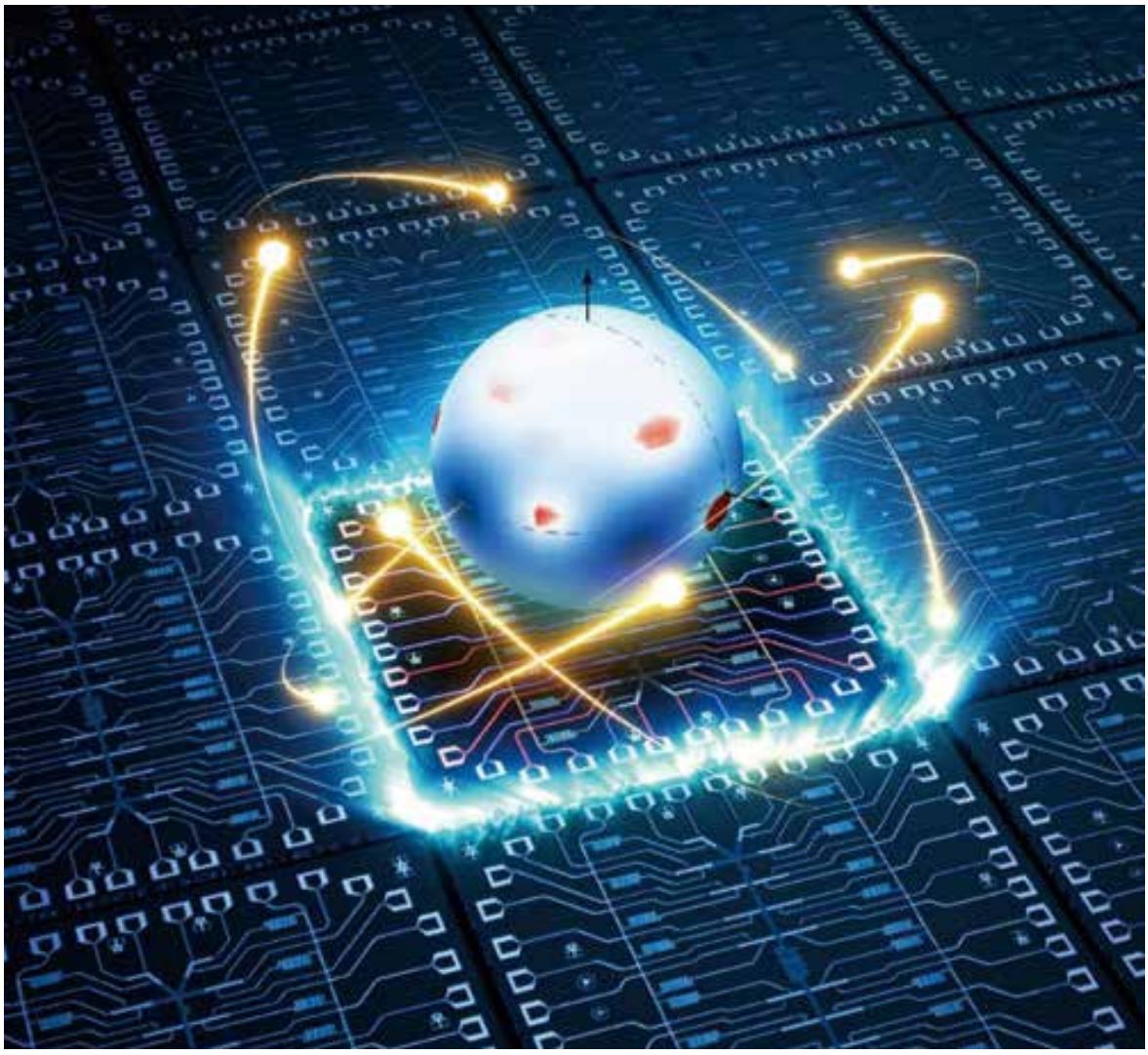

Figure 2: Device with 20 superconducting qubits and states distribution on Bloch sphere. (Image by authors from Zhejiang University and IOP)