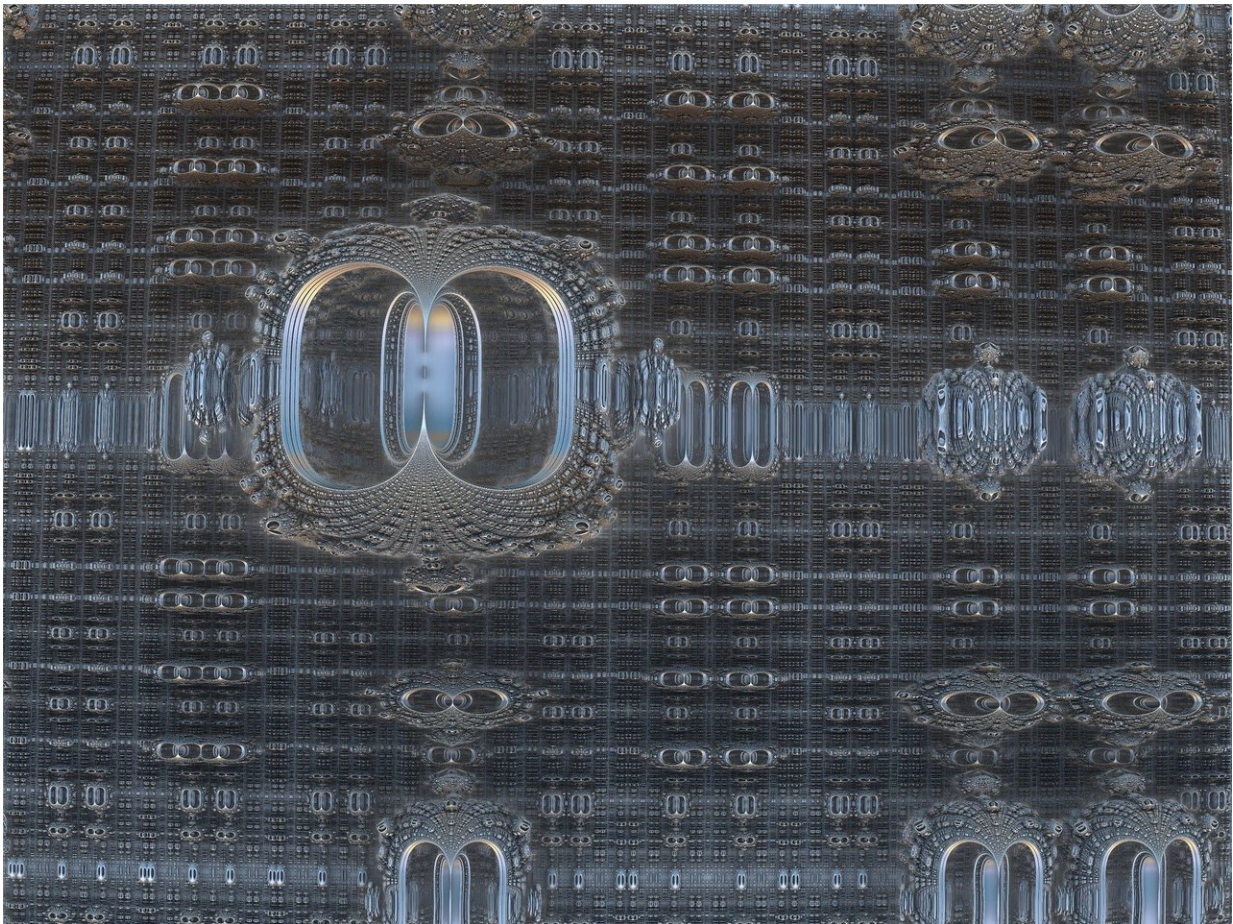


Researchers achieve multifunctional solid-state quantum memory

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The team of Li Chengfeng, Zhou Zongquan and others from the CAS

Key Lab of Quantum Information developed a multi-degree-of-freedom (DOF) multiplexed solid-state quantum memory, and demonstrated photon pulse operation functions with time and frequency DOFs. The results were published in *Nature Communications* recently.

The reliable storage and coherent manipulation of quantum states with matter-systems enable the construction of large-scale quantum networks based on a quantum repeater. To achieve useful communication rates, highly multi-mode quantum memories will be required to construct a multiplexed quantum repeater.

The team presented the first demonstration of the on-demand storage of orbital-angular-momentum states with weak coherent pulses at the single-photon-level in a rare-earth-ion doped crystal. Through the combination of this 3-dimensional spatial DOF with 2-dimensional temporal and 2-dimensional spectral DOFs, the team created a multiple-DOF memory with high multi-mode capacity up to $3 \times 2 \times 2 = 12$.

This device can also serve as a quantum mode converter with high fidelity, which is the fundamental requirement for the construction of a multiplexed quantum repeater.

The team further demonstrated that the device can perform arbitrary pulse operations within time and frequency DOF. Representative operations include pulse sequencer, multiplexer, selective spectral shifter and configurable beam splitter. The experimental results showed that in all these operations, the three-dimensional quantum states carried by photons maintained a fidelity of about 89%.

This memory device can achieve all operations required for Knill-Laflamme-Milburn type quantum computation, so it may be expected to find application in the field of linear optical quantum computing.

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