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Researchers achieve on-demand storage in integrated solid-state quantum memory

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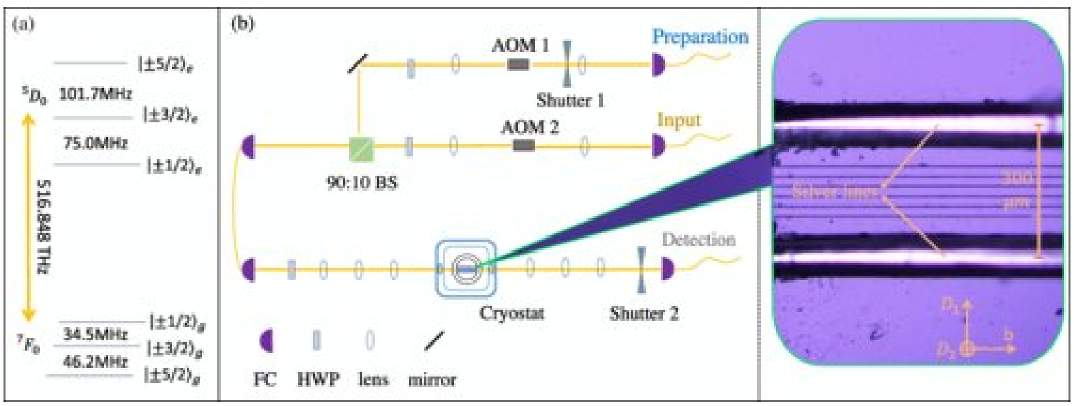

Figure 1 (a) Level structure of 151 Eu 3 + ions at zero magnetic field. (b) Diagram of the experimental setup. The acoustic optic modulators labeled as AOM 1 and AOM 2 are employed to generate the preparation and input beams. The input and preparation beams are combined by a beam splitter (BS) with a reflection-to-transmission ratio of 90 : 10 . The combined beam is coupled into the waveguide and then collected into a single-mode fiber with a lens group. The mechanical shutter 1 and shutter 2 ensure that the single-photon detector is protected from the strong preparation light. Inset: top view of the on-chip quantum memory under a microscope. Six tracks are fabricated on the sample with a spacing of 23 μ m , forming five type IV waveguides. The central one with the minimum insertion loss is employed for the quantum storage. Silver lines provide the electric field for storage time control. FC: Fiber coupler, HWP:half-wave plate. Phys. Rev. Lett. 125, 260504

Researchers from CAS Key Laboratory of Quantum Information of the

University of Science and Technology of China (USTC) of the Chinese Academy of Sciences have demonstrated on-demand storage of photonic qubits in an integrated solid-state quantum memory for the first time. This work was published in *Physics Review Letters*.

Quantum memory is the core technology for building large-scale quantum networks. Quantum repeaters or quantum hard drives, based on quantum memories, can effectively overcome photon loss in the channel, thus extending the working distance of quantum networks.

On-demand storage requires determination of the storage time after the photon has been absorbed by the quantum memory, which is essential for quantum networks. However, integrated solid-state quantum memories demonstrated so far are all based on the atomic frequency comb (AFC) scheme with a predetermined storage time.

In order to achieve on-demand storage, the researchers adopted a modified quantum memory scheme: the Stark-modulated AFC scheme. They made use of the Stark effect to manipulate the evolution of the rare-earth ions in real-time by introducing two electrical pulses to control the storage time of the quantum memory.

The researchers first used a femtosecond laser micromachining (FLM) system to fabricate optical waveguides on the surface of a europium-doped yttrium silicate crystal, and then placed two on-chip electrodes on both sides of the optical waveguides, so that the storage time could be controlled in real-time with a transistor-transistor logic (TTL)-compatible voltage. The insertion loss of the optical waveguide was below 1 dB, which is currently the best value reported for integrated solid-state quantum memories.

They demonstrated on-demand storage of time-bin qubits with such integrated solid-state quantum memory, with a storage fidelity of

99.3%±0.2%. This result is close to the best storage fidelity achieved with in bulk crystals (99.9%, PRL108, 190505) which was also reported by the same research group in 2012. The high fidelity indicates the reliability of this integrated quantum memory.

This work is of great importance for building large-capacity quantum memory and constructing quantum networks.

More information: Chao Liu et al. On-Demand Quantum Storage of Photonic Qubits in an On-Chip Waveguide, *Physical Review Letters* (2020). DOI: 10.1103/PhysRevLett.125.260504

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