Quantum Memory Manipulation via a Fiber Optic Ring Resonator

P. Chunpang, C. Sripakdee and P.P. Yupapin
Lightwave Technology Research Center, Department of Applied Physics
Faculty of Science, King Mongkut's Institute of Technology Ladkrabang
Bangkok 10520, Thailand, yupapin.preecha@kmitl.ac.th

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Abstract

This study shows the idea of a simple method to characterize an optical/quantum memory. The principle of this study is that a laser pulse with wavelength of 1550 nm is launched into a single mode fiber coupler (50% fiber coupler) via an optical time domain reflectometer (OTDR) as shown in Figure 1, i.e. an optical resonator is formed by using a 2x2 coupler. Light pulse from OTDR with pulse width of 200 ns is launched and propagated along a ring resonator for a period of time (i.e. memory) while being attenuated by Raleigh back-scattering. This backscattered light also circulates in the resonator and part of it is directed to the OTDR. However, the signal in a ring fiber resonator can be amplified by using a pump laser with wavelength of 980 nm and an Erbium fiber.

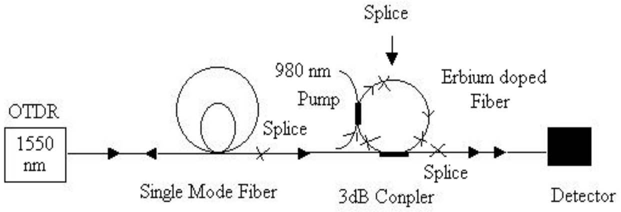

Figure 1. An experimental setup.

This recirculation of signal is combined together with the recirculation of Raleigh backscattered light in fiber cavity allows different Raleigh contributions to be detected simultaneously. In practice, the detected pulse delay time and number of pulse could be controlled by using an appropriate cavity length and input pulse width, then the required pulse width and number of pulse/photon may be realized for the required applications. To implement a quantum memory, we have to consider that the information of quantum memory is limited by photon relaxation time.

We present here the realization of a quantum memory generates in an optical ring resonator. The initial photons were either in one of its two forms (entangled photon), or in superposition of them. The optical fields were observed either 0(without signal) or 1(with signal) photon or in a super position of them as shown in Fig. 2, where the signals with nine roundtrips were observed. Figure 3 shows a plot of the experimental result of light in four roundtrips around the ring resonator. The optical pulse with pulse of few ns, memory time of 5 μs is obtained with four roundtrips in the resonator. The decay of the signal amplitude of Figure 2 is plotted in Figure 4.

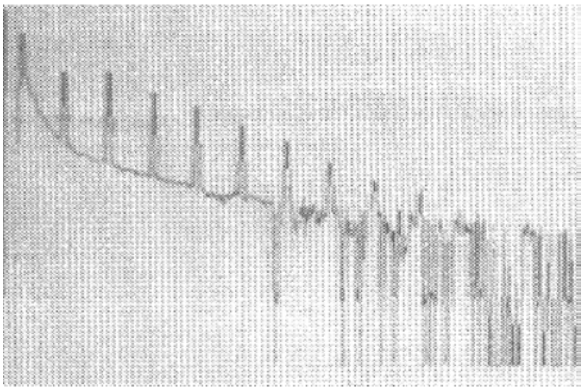

Figure 2. Experimental results

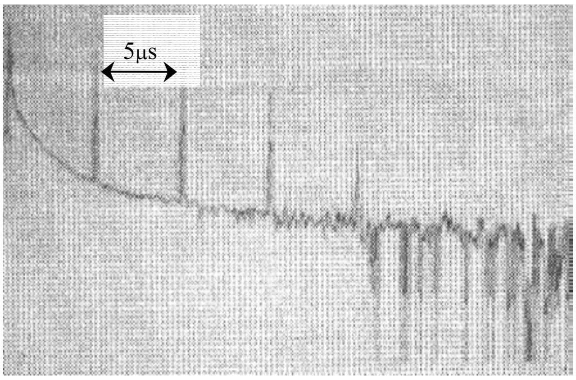

Figure 3. Experimental results.

The qubit in the form of 0 and 1 could be assigned by using to the detected signals on the detector. In practice, the required memory time may be obtained by using a certain resonator length and an attenuate fiber optic type as a ring resonator part. The entangled photon study can be realized by using this scheme, then the quantum cryptography or quantum transmission by connecting to a delivery optical fiber can be implemented.

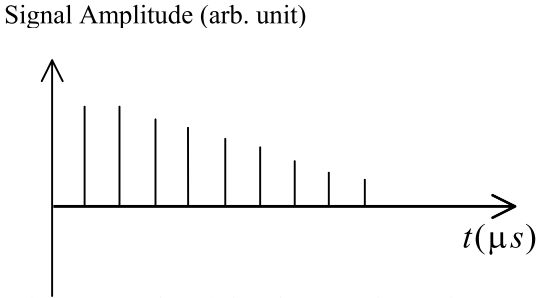

Figure 4. A plot of signal attenuation and memory time (delay time).

By varying the delay time of the input pulse, we can measure the qubit holding time of the cavity. i.e. quantum memory. We can directly determine in this way the lifetime of a single photon and of a superposition of 0 and 1 photon. To generate a single photon, an optical input pulse from OTDR was launched into an optical ring resonator, where a single output pulse was occurred in the experimental process with some repeat roundtrips, then a single photon was generated. This scheme may be used to incorporate with more optical components i.e. polarizer, polarizing beam splitter, then a polarization photon may show the entanglement property.

In conclusion, we have shown that an optical pulse i.e. single photon is obtained at steady state with pulse width of few nanoseconds using this technique. Which may be used to generate the entangled photon for quantum cryptography application. The study of the entangled photon transmission and long haul quantum communication may be realized by using this merit scheme.

References

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