Plasmonic Coherent Perfect Absorption and Switching in a Fiberized Quantum Network

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In this report we provide the first demonstration of a fully fiberized quantum network with a fiber-integrated metamaterial as a dissipative switching element. Using the phenomenon of coherent absorption in plasmonic metamaterials we achieve high-contrast control of the single photon absorption probability and demonstrate switching application.

While the absorption of photons from a travelling wave is probabilistic, standing wave absorption can be observed deterministically, with nearly unitary probability of coupling a photon into a mode of the material, for example, a localized plasmon when a metamaterial is excited at the plasmon resonance. This process has been used in various forms of switching applications in particular for demonstration of classical logical functions XOR, NOT and AND with CW and short-pulse lasers.

Here we demonstrate manipulation of light at a single photon level in an all-fiber-optic quantum network (Sagnac-like interferometer, Fig. 1) with a fiber-integrated plasmonic absorber (Fig. 2a) which is interrogated by the heralded down-converted single photon source. We have achieved continuous control of the single photon absorption probability with visibility of 80% (Fig. 2b) by altering phase retardation in one arm of the interferometer. Our experiments were performed in two regimes: 1) in a quantum network actively stabilized on with independent laser source; 2) in a free-running network without stabilization by algorithmic post-selection of the data. We also demonstrate single photon switching regime (Fig. 2c) with active phase modulation, showing the ability of driving the quantum network in time-domain between coherent single photon transmission and absorption regimes.

Our results demonstrate that stabilized and free-running fiber networks can be robustly used in dissipative single photon switching, thereby presenting powerful opportunities for novel coherent optical data processing architectures and complexity oracles.

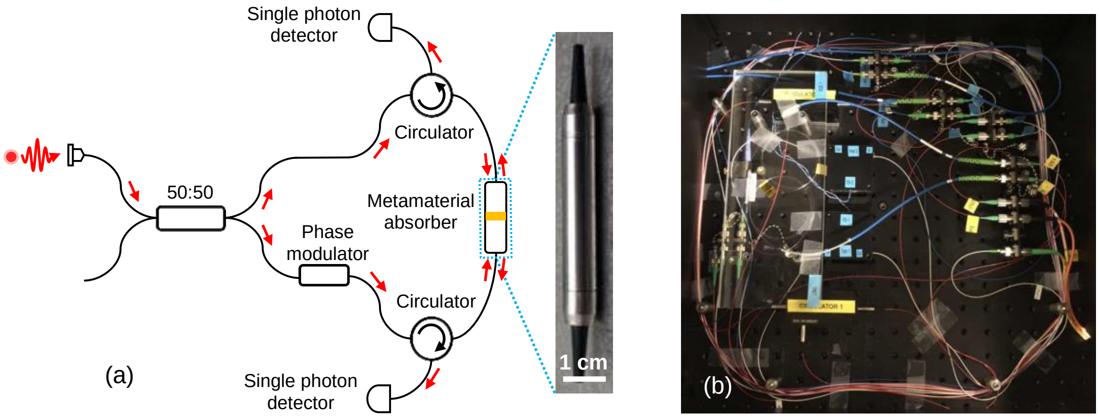

Figure 1. All-fiber-optic quantum network for active single photon switching using a fiberized plasmonic metamaterial absorber (inset shows a photograph of the packaged metadevice): (a) schematics; (b) photograph.

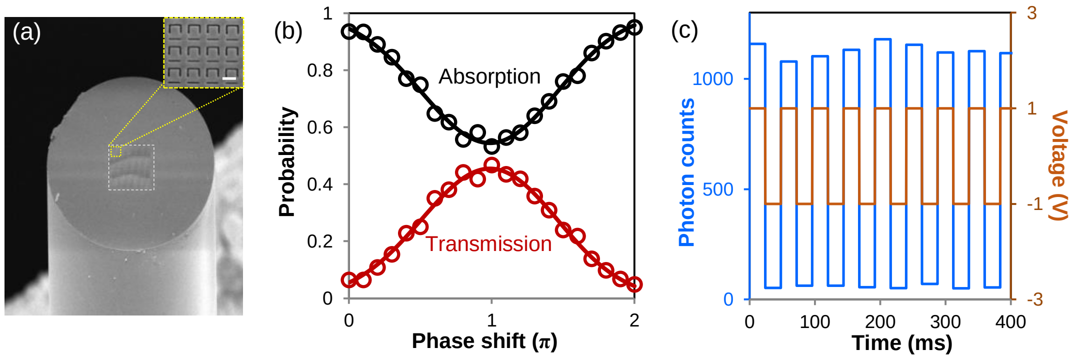

Figure 2. (a) SEM image of the plasmonic metamaterial absorber deposited on the end-facet of the optical fiber (inset shows the SEM image of individual asymmetric split ring resonators, scale bar is 500 nm); (b) Single photon absorption and transmission probability by continuous phase shift modulation; (c) Demonstration of single photon switching with 20 ms acquisition time: blue line shows the photon counts level, brown line shows the control voltage applied to phase modulator.