Achieving nonreciprocal unidirectional single-photon quantum transport using the photonic Aharonov-Bohm effect

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It has been recently found that the phase of the dynamic modulation can provide an effective gauge field for photons in the photonic structure undergoing dynamic modulation, which exhibits a photonic Aharonov-Bohm (AB) effect, in both real space [1] as well as in spaces that involve a synthetic frequency dimension [2]. Here, we will show that a nonreciprocal unidirectional transport can be achieved in the single-photon limit. A system composed of a 1D waveguide coupling to two V-type atoms are explored. External coherent fields drive the two atoms respectively, and the phase of the external fields provides the effective gauge potential for photons. A proper choice of the phase difference gives a unity contrast in the transmissions for the two propagation directions in the single-photon limit (see Fig. 1) [3]. Our work opens a new possibility for the control of single photon transport and the study of novel quantum many-body photonic states.

FIG. 1: Transmissions [for photon of type 1 (a) and for photon of type 2 (c)], and reflections [for photon of type 1 (b) and for photon of type 2 (d)] spectra when the photon of type 1 is incident from the left end (red curves) or from the right end (blue curves) into the waveguide system with two driven atoms (e) [3].