

Optical Precursor of a Single Photon

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Physics Synopsis



Editors' Suggestion

We report the observation of optical precursors of heralded single photons. With electromagnetically induced transparency (EIT), we separate the single photon precursor, which always travels at the speed of light in vacuum, from its delayed main wave packet. In the two-level superluminal medium, our result suggests that the causality holds for a single photon.

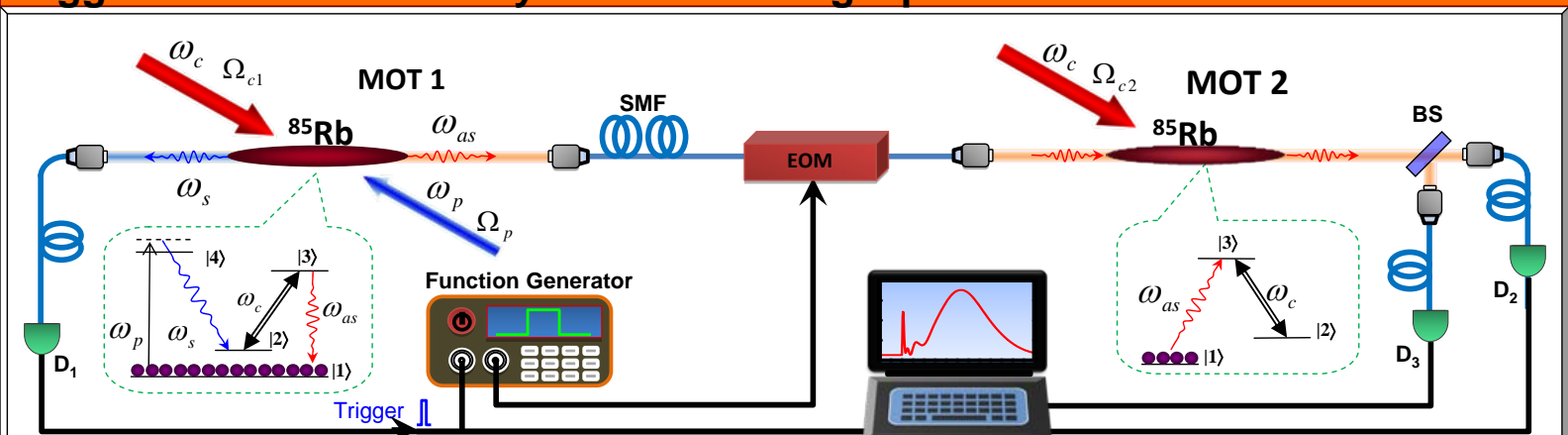


FIG. 1: Experiment setup for observing single photon optical precursors.

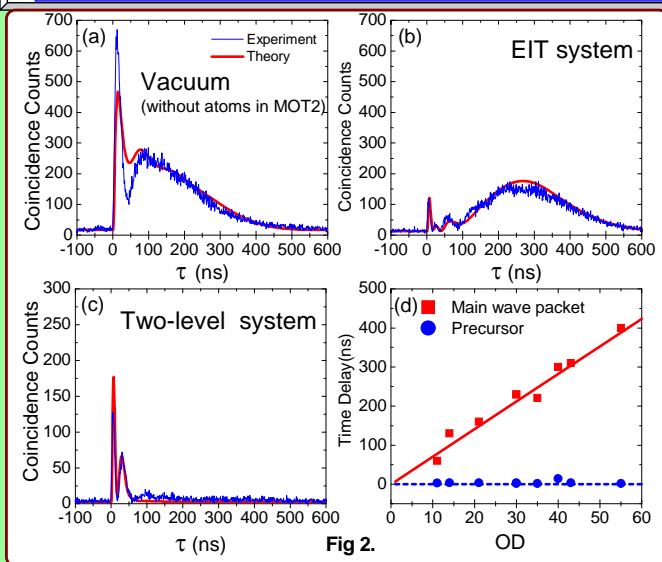


Fig 2.

FIG. 2: Separation of optical precursors without modulation.

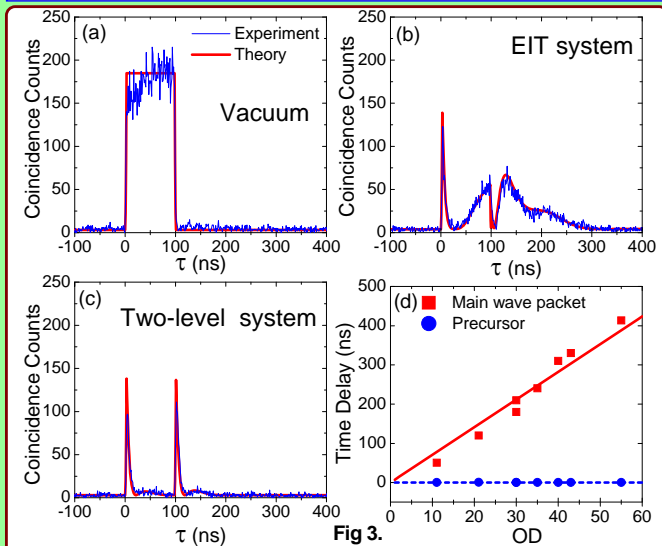
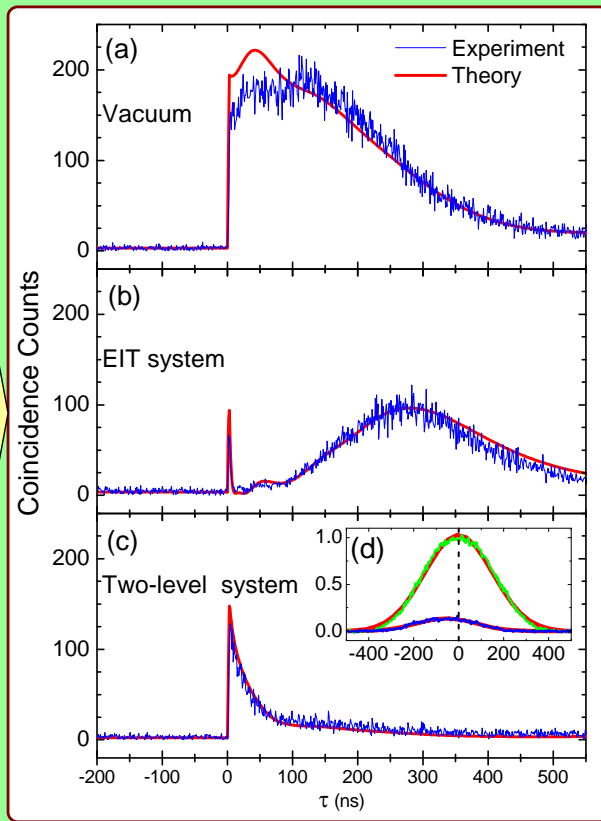


Fig 3.

FIG. 4: Single-photon optical precursors from a square amplitude modulation.

FIG. 3: (a) The heralded anti-Stokes photon waveform with a step modulation. (b) and (c) are the waveforms after the photon passing through the EIT system and two-level system in MOT2, respectively. Inset (d) shows a Gaussian pulse propagation in the two-level system with a peak advancement of about 40 ns (the lower curve) compared to the reference pulse (the up curve).



SPEED LIMIT
C

A Single Photon Obeys the Speed Limit!

As shown in Fig. 3(c), even in the two-level system where the group velocity is negative, we observe no component of a single photon moving faster than the rising edge and its precursor. In other words, there is no probability for a single photon traveling faster than the speed of light in vacuum c . Our result suggests that a single photon obeys the speed limit.