Netiesinis dažnio keitimas ir interferometrija su lėta šviesa

Nonlinear frequency conversion and interferometry with slow light

Viačeslav Kudriašov[1], Julius Ruseckas[1], Gediminas Juzeliūnas[1],
Meng-Jung Lee[2], Chin-Yuan Lee[2], Kao-Fang Chang[2], Hung-Wen Cho[2], Ite A. Yu[2]
[1]Institute of Theoretical Physics and Astronomy, Vilnius University, Saulėtekio 3, Vilnius LT-10257, Lithuania
[2]Department of Physics and Frontier Research Center on Fundamental and Applied Sciences of Matters,
National Tsing Hua University, Hsinchu 30013, Taiwan
viaceslav.kudriasov@ff.vu.lt

Spinor slow light (SSL) was recently proposed as a novel slow light modification scheme enabling to achieve unusual optical effects in quantum media [1,2]. The SSL may lead to the interesting physics such as spinor Bose–Einstein condensation of dark-state polaritons and Dirac particles. Particularly, formation of SSL polaritons exhibiting Dirac energy spectrum and oscillations between the frequency components were studied using a double tripod (DT) scheme [2,3]. Among the interesting effects to be studied are the nonlinear frequency conversion processes, especially at a single-photon level.

We demonstrated that by varying one of the three factors in the DT, the two-photon detuning, optical density (OD) and coupling field Rabi frequency, the spinor slow-light outputs oscillate alternatively [3]. Regarding the nonlinear optical process that converts light from one frequency to another, high conversion efficiencies (up to 96%) can be achieved for an OD of 250 in the DT scheme. The same efficiency would require an OD of 500 in the widely used double-lambda scheme [4]. Hence, the DT is a new and advantageous scheme for nonlinear frequency conversion. Current setup was arranged in a beam co-propagation configuration, which allows for a higher efficiency as compared with the counter-propagating one.

In a proof-of-principle measurement, our study shows that the DT scheme for the light storage behaves like the two outcomes of an interferometer enabling measurements of the frequency detuning with high precision (Fig. 1). With such an interferometer one can precisely determine the two-photon detuning in the system. We utilized the sufficiently long decay time constant of stored light (~76 μs) for these measurements [4]. The measured value of the difference is consistent with the actual one, showing that the light-storage DT scheme can be used to determine the detuning or anything that can affect it, such as light shifts, Zeeman shifts, and so on. The precision demonstrated was of the order of 100 Hz.

Furthermore, we demonstrated a possible application of employing the DT scheme as quantum memory/rotator for the two-colour qubits by utilizing a two-photon detuning during the storage time. The single-photon SSL can be considered as the qubit with the superposition state of two frequency modes or, simply, as the two-colour qubit. Such a qubit can be produced by sending a single photon to the DT system. It was demonstrated that the storage of light in the DT system preserves the superposition coefficients [3].

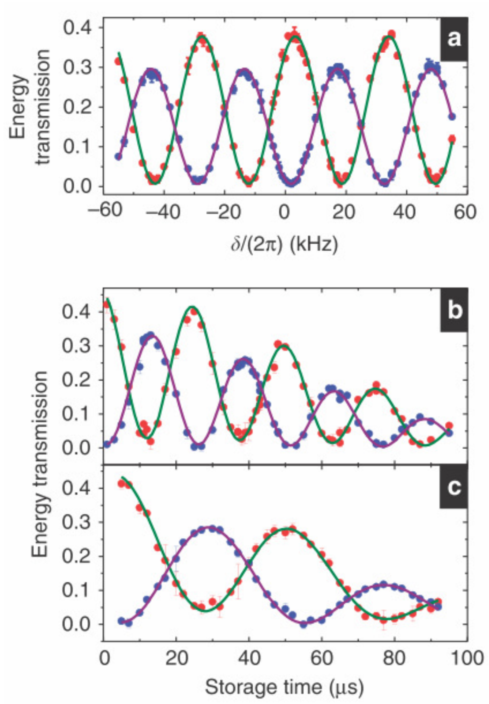

Fig. 1. Light storage in the double-tripod scheme.

Keywords: double tripod, light storage, optical density, interferometer, two-color quibit.

Literature

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