Similar-Shaped Pulse Generation in Double-Lambda System

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The effect of matched pulses establishment in four-level system was investigated in [1] for the case of long pulses. The case of short pulses (pulse durations are less than all the relaxation times of a medium) was considered in [2] using numerical simulations. Now we found that the short pulse case has new analytical interpretation. It can be treated as the superposition of dark-state polaritons (studied in [3] for three-level Λ-system) and simultons (presented in [4] for three-level V-system). The propagation velocity of simulton is proportional to the intensity of probe pulses with Rabi frequencies $G_{1,4}$ (interacting with the ground state). The propagation velocity of polariton is proportional to more intensive coupling pulses (resonant to adjacent transitions) with equal Rabi frequencies $G_{2,3}$. Simultons propagate slowly and become detached in space. And segregated polariton component acts as matched pulses. Any initial superposition evolves to distinguished simultons and a couple of similar-shaped dark-state polaritons.

A four-level system in the double-Λ configuration is shown in Fig. 1. Probe pulse with Rabi frequencies $G_{1,4}$ are less than the coupling pulses $G_{2,3}$. Coupling pulse areas need to be one order greater than unity. The case of exact resonance for all pulses is assumed. At the entrance of the medium probe pulse G_4 is absent (Fig. 2). But it is generated in the medium by nonlinear mixing. It becomes identical to G_1 pulse (Fig.3). The part of initial intensity concentrates in similar-shaped polariton component (Fig. 4), and the other part slows down in simulton component. Initial probe pulse shape is arbitrary.

Polaritons do not populate two high-energy atomic levels. And simultons induce no atomic coherence at the dipole-prohibited transition between two lower states. So, solitary wave of simulton is able to cross the double similar-shaped dark-state polariton with negligible distortion (Fig. 5). For modeling the numerical calculations of Maxwell-Bloch equations were used.

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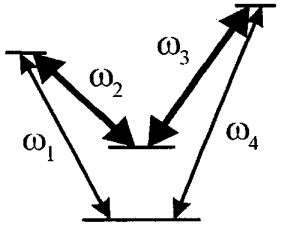

Fig. 1. Double-Λ scheme.

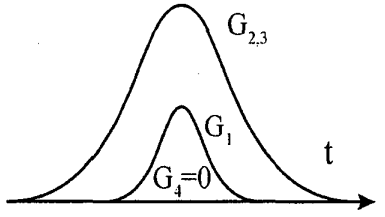

Fig. 2. Pulses at medium entrance.

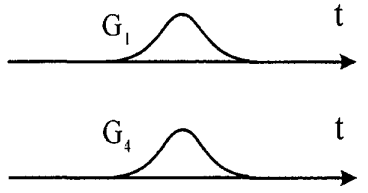

Fig. 3. Similar-shaped pulses.

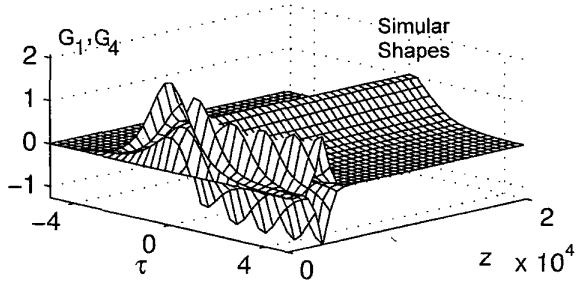

Fig. 4. Establishment of similar shaped probe pulses.

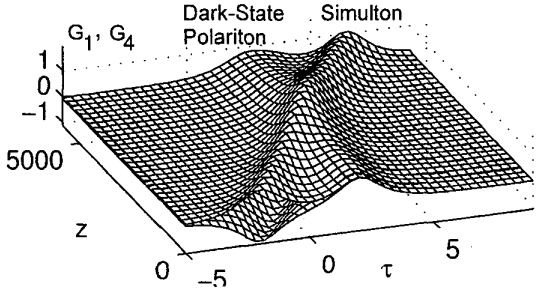

Fig. 5.Simulton interacts with Dark-State Polariton.