Two-level atoms driven by two ultrashort pulse trains: coherent accumulation and photon echo generation

Gabriel N. Nogueira, Marco P. Moreno

Universidade Federal de Rondônia

We investigate theoretically the coherent accumulation process in a Doppler broadened two-level system excited by two ultrashort pulse trains with the same repetition period, but with a delay \( \tau \) between them. Our interest is the regime when the system is excited by a sequence of pair of optical pulses many times within the lifetime of the upper state [1,2]. The Bloch differential equations are solved numerically in the rotation wave approximation, using the standard fourth-order Runge-Kutta method and considering the \( 5S_{1/2} \rightarrow 5P_{3/2} \) transition of rubidium vapor. We analyze the temporal evolution of both upper state population and coherence for different values of \( \tau \). We also studied the dependence of these density matrix elements as a function of the atomic group velocities, where the frequency comb is “printed” in the Doppler profile [3]. Finally, the theoretical model is applied to the study of the generation of photon echoes. In this case, the macroscopic polarization is integrated over the Maxwell-Boltzmann distribution velocity from the off-diagonal matrix density elements. When three pulses (\( \pi/2 \rightarrow \pi \rightarrow \pi/2 \), “stimulated photon echoes”) drive the system, are obtained two echo pulses, exactly as reported in previous works [4]. We conclude the work by discussing the photon echoes pattern generated by the pulse pair sequence. This work was supported by CNPq and FAPERJ (Brazilian Agencies).