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Reversible absorption of weak fields revealed in coherent transients

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Abstract

It is shown that the absorbtion of a weak field in a thick resonant absorber is a reversible process even in the case of the homogeneous broadening of the absorption line. As an example, the propagation of a long rectangular pulse with sharp edges in an optically dense resonant medium is studied theoretically in the linear response approximation. Transient nutation (TN), free induction decay (FID), and transients, induced by the phase switch of the incident pulse, are considered. It is shown that in exact resonance the amplitude of FID increases with the length of the medium. FID arises due to the scattered radiation field (dipoles ringing). In a thick medium the scattered field is almost of the same amplitude but opposite in phase with the incident radiation field. Both fields interfere destructively to produce what is seen as radiation damping at the output of the medium. The scattered field needs time to develop. Therefore, the leading edge of the pulse is not absorbed, demonstrating temporal transparency followed by TN. Phase shift (180) of the pulse brings the incident pulse in phase with the scattered radiation. Constructive interference of the pulse with the scattered radiation field produces a short pulse with an amplitude that is two times larger than the amplitude of the incident pulse. If the input pulse is detuned from resonance, for a particular detuning and optical thickness of the medium the amplitude of the transient pulse, induced by the phase shift, is nearly three times larger than the amplitude of the incident pulse. This is explained by the interference of the scattered field, the phase-shifted input field, and the slowly propagating part of the pulse, developed before the phase shift.

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