Vanishing the delay of a light pulse induced by propagation in matter

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Any transmission line of some extent presents two key steps: propagation in a slow media (respect to the vacuum) with reduction of the signal amplitude and a further propagation in an amplifying media. The aim is to recover the delay induced by propagation in matter.

Our idea is to combine, in a proof of principle experiment, the delay induced in a slow light propagation with a subsequent "superluminal" propagation in an amplifying medium. In addiction we show that this possibility can be optically controlled [1].

In recent years, research in controlling propagation dynamics of optical pulses has been able to achieving extremely low group velocities ("slow-light"- regime) [2] or superluminal group velocities ("fast-light"-regime) [3]. In the fast-light case, the pulse peak is in advance in propagation respect to vacuum-case, in a way consistently with special relativity and causality [4]. We showed theoretically [5] and experimentally [6,7] that is possible to achieve an incoherent optical control of propagation dynamics of an optical pulse both in slow-light case and in fast-light case for a pulse of 3 ns of time duration.

The experimental set-up consists in two cells filled with hot sodium vapor at low pressure and two control pulses, resonant with different atomic transitions, in order to produce a passive medium in the first cell and an active medium in the second one. In a subsequent time, a probe pulse, with central wavelength tuned near resonance with an atomic transition, experiments an extra-delay in the first cell, because of normal dispersion properties probed in the passive medium, and an advance in the second one, because of anomalous dispersion zone in the active medium.

Results showed that the second fast-light stage can be controlled by the control pulse to not only completely recover the previously induced delay in the first slow light stage, but also produces an advance, respect vacuum propagation, equals to the case of the first stage switched off.

In this way the previous history of the pulse propagation can be canceled in a timescale of 1.0 ns.

Our experiment may also lead to interesting scenarios in optical signal transmission, with adding to the necessary amplification stage an optical control upon the recover of the propagation delay.

References

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