Slow/Fast-Light Scheme for achieving propagation at “true” c-velocity for an optical pulse

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In recent years, many experimental works in optics were been directed in controlling propagation dynamics of optical pulses, in particular in order to achieving extremely low group velocities (“slow-light”- regime) or superluminal or negative group velocities (“fast-light”-regime). 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.

Although many experimental schemes proposed in literature exploit coherent effects, like electromagnetic-induced transparency, we showed theoretically [1] and experimentally that is possible to achieve an incoherent optical control of propagation characteristics of a laser pulse both in slow-light case [2], with induced delay up to 15 ns, and in fast-light case [3], with advances up to 1 ns, for a pulse of 3 ns of time duration.

These results suggested the opportunity to combine the two effects, in a same experimental set-up, in order to explore possibility of recovering a delay, induced by slow-light interaction, with a subsequent fast-light propagation stage. The experimental set-up consists in two cells filled with hot sodium vapor at low pressure and two pump 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 is not only able to completely recover the previously induced delay (up to 1 ns order), but also produces an advance, respect vacuum propagation, equals to the case of the first slow-light stage switched off. This kind of “advance saturation” suggests a “true propagation at c-speed” for an optical pulse envelope previously delayed. Such experimental work might open interesting scenarios in optical signal processing, because of the final fast-light stage could be used in order to cancel previous history in propagation dynamics, acting as a kind of a “temporal invisibility cloaking” device.

References:

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