Laser written waveguides in glasses and crystals

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Waveguides for integrated optical applications are usually made by indiffusion of ions into crystal or glass materials. However, the generation of three-dimensional structures is hard to achieve. This problem can be overcome by laser generated waveguides.

Ultrashort laser pulses focused inside optical transparent bulk materials create local structural changes. An example is the generation of three-dimensional material. The sample was fixed on a computer-controlled XYZ stage.

Fig. 1

Wave approximation is abandoned.

Generation of waveguides in fused and crystal silica is presented. Properties of the waveguides are discussed.

Photon Echo Spectroscopy in the Single Optical-Cycle Regime

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A very high temporal resolution and a broad bandwidth are two advantages provided by the use of extremely short sub-5 fs pulses [1] in a nonlinear spectroscopic experiment. However, the applicability of the standard theoretical description becomes questionable for the pulses that consist merely of a couple of optical oscillations. For instance, the conventionally employed slowly varying envelope approximation, implying that the change of the pulse envelope on the duration of an optical cycle is negligible compared to the magnitude of the amplitude itself, can no longer be maintained. Furthermore, the phase-matching bandwidth that is limited due to dispersion in the nonlinear medium rapidly goes to zero with the increase of the spectral width of the pulse. Another point of serious concern is the frequency-dispersive variation of the sensitivity of signal photodetectors. In combination, the above listed features result in what is known as a spectral filter effect. Finally, the realization of the experimental transient is a direct consequence of the nonlinear geometry employed in spectroscopic experiments.

In this contribution we present a theoretical analysis which thoroughly reexamines the formalism of ultrafast photon echo spectroscopy. We obtain a general representation for the echo signal, which is valid even for single-cycle-pulse applications. The derived formalism is applied to photons-echo spectroscopy on the hydrated electric with 5-6 pulses.

According to our calculations, a careful choice of the beam geometry and selection of a photodetector with the suitable spectral sensitivity allows the otherwise damaging role of the spectral-filter effect as well as that of geometrical selecting. Importantly, for the weak-signal applications such as photon echo spectroscopy, the absence of spectral filtering eliminates the otherwise unavoidable requirement to frequency-resolve the signals.

Figure 1 presents two-phase echo signals obtained from the main water and electrons, solution in water. A minute difference in the widths of these two traces suggests that the electronic dephasing of the hydrated electrons is extremely fast. The finite population lifetime of the electrons in the excited state causes the delay of the echo trace in Fig. 2.b. The best fit to the experimental data yields a pure dephasing time of $T_2 = 1$ fs. With this value, the above results of the hydrated-electron can be successfully modeled provided the conventionally used rotating wave approximation is abandoned [2].

References

Fig. 2. Results of incoherent photon echo experiments on water taken (a) and hydrated electrons. The solid curves show results of simulations.