

Measurement of ultrashort laser pulses using a non-linear optic method

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Abstract

Ultrashort laser pulses are extremely important in the studies of ultrafast phenomena, so it's fundamental to know the laser pulse duration to make these studies possible. Ultrashort laser pulses cannot be measured directly, and an optical method is required to measure these pulses: the autocorrelation. Exploring the non-linear properties of a BiBO crystal, it's possible to build an autocorrelator and precisely measure the duration of an ultrashort laser pulse. Using the Second-Harmonic Generation property, the characterization of tunable spectrum laser was made, getting the relation between the pulse width and spectrum width.

Key words:

Non-linear Optics, Ultrafast Phenomena, Ultrafast Laser Pulses.

Introduction

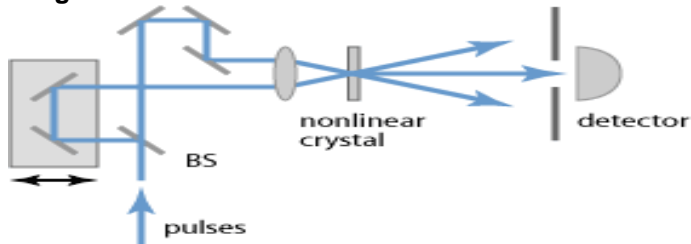
In order to measure an ultrashort laser pulse, it is necessary to use an optic method to get the results. Exploring the property of second-harmonic generation of a BiBO Crystal, an autocorrelator was built in order to measure the laser pulses.

The pulses are generated by a tunable spectrum laser, that changes the laser pulse duration. The main goal of this project is to characterize this laser pulse duration according to the spectrum width for different spectrum center

Results and Discussion

In order to measure the ultrashort laser pulses, we need an autocorrelator (the experiment schematic is shown in Figure 1) that was built in the lab. The pulse is divided by a beam splitter in two arms, one of them has a corner cube mirror attached to a speaker and the other one is fixed, then they get into a convergent lens and meet in the focus of this lens, where a non-linear crystal is put. This non-linear crystal has second order non-linear properties, such as second harmonic generation.

Image 1. Schematics of the autocorrelator

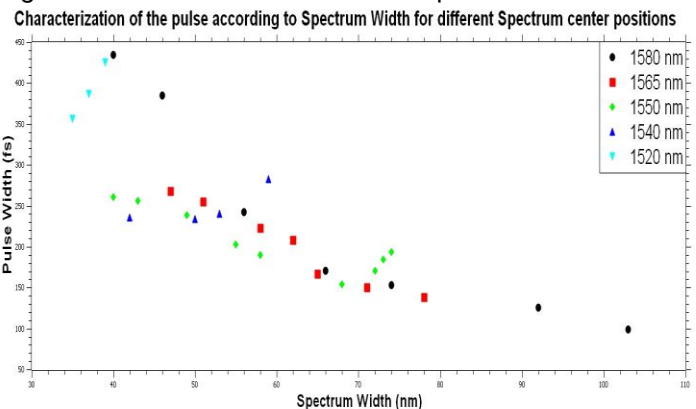


Alongside with building the experiment, an introductory study in non-linear optics was made in order to understand the concepts involved in the experiment. We wish to generate second harmonic using the crystal, but to obtain the autocorrelation signal we need to get the two pulses together in both time and space, and achieve the phase matching condition. Exploring the birefringence of the crystal, we can have different effective indexes just by rotating the crystal, so the phase matching condition becomes $n_e(\omega_1) = n_e(2\omega_1, \theta)^1$, which has a solution for an angle θ , efficiently generation the second harmonic. After getting the second harmonic, the autocorrelation signal was got. Using the autocorrelation width (ΔT), we

can get the actual width of the pulse using the relation $\tau = \gamma \times \kappa \times \Delta T$, where γ is a conversion factor obtained by a calibration process moving the fixed arm of the autocorrelator and κ is a coefficient depending on the shape of the pulse.

Changing the spectrum, we got the characterization of the pulse in Figure 2:

Figure 2. The characterization of the pulse



Conclusions

With the second harmonic generation, we obtained the autocorrelation signal, as expected (Autocorrelation

$$G^{(2)}(\tau_d) = \int_{-\infty}^{+\infty} I(t)I(t + \tau_d) dt$$

equation²: The characterization showed that for the spectrum centered at a wavelength $\lambda_0 > 1550$ nm the pulse duration decreases as the spectrum width increases, and for $\lambda_0 < 1550$ nm, the pulse duration increases as the spectrum width increases. The pulses durations vary between 450 fs and 90 fs, but we know it can be bigger than 450fs, even though we cannot measure it, because of the weak second harmonic signal. These values don't count the dispersion of the components of the autocorrelator.

Acknowledgement

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¹ Robert W. Boyd, Nonlinear Optics, Third Edition, Academic Press, 2008.

² Carlos H. Brito Cruz, Hugo L. Fragnito; Fenômenos Ultrarápidos: Geração de Pulsos Laser Ultracurtos e Suas Aplicações, 2000