Broadband Intensity Autocorrelator with 3Doptix

BACKGROUND

Ultrafast lasers (with pulses ranging from few femtoseconds to few picoseconds) have become over the last decade cornerstone in many optical setups with applications in Ultrafast Physics, Nonlinear Spectroscopy and Microscopy, material processing and nanofabrication AND nonlinear optics. However, THE unique temporal properties OF THESE LASERS, faster than modern optoelectronic detectors, call also for unique characterization challenges. In the past two decades, ultrafast characterization tools based on nonlinear interaction were invented. Among them we can find autocorrelators, cross-correlator and FROG (Frequency-Resolved Optical Gating) making it a must have in any setting using ultrafast laser.

Intensity autocorrelators address this challenge and offer a relatively accessible tool for the characterization of ultrafast lasers pulse width. Such intensity autocorrelators are schematically described in figure 1 below.

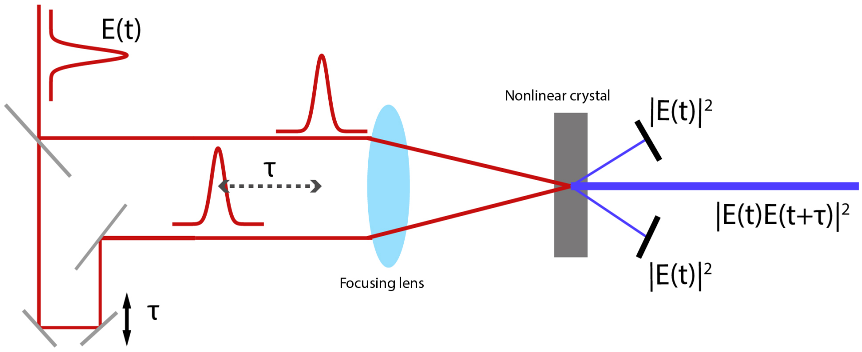

Figure 1: Intensity Autocorrelation schematic

The laser pulse to be measured, of complex electric field E(t), is split into two pulses (generally using a beam-splitter). The two pulses are then delayed one with the respect to the other and focused onto a nonlinear crystal.
The generated second harmonic signal is proportional to $(E(t)+E(t+\tau))^2$. By retaining the beam propagating on the optical axis, proportional to the cross-product $E(t)E(t+\tau)$, we therefore record on the detector the intensity autocorrelation $I(\tau)$:

$$I(\tau)=\int_{-\infty}^{+\infty} |E(t)E(t+\tau)|^2 \, dt=\int_{-\infty}^{+\infty} I(t)I(t+\tau) \, dt$$

It can readily be seen that this setup requires many degrees of freedom to maintain a precise overlap of the two incident beams on the nonlinear crystal while scanning the delay line. Moreover, generally relying on bulk beam splitters and refractive optics, commercial versions of this setup are limited in their spectral range of operation. In this application note we introduce the 3DOptix broadband Intensity correlators that addresses and alleviates these limitations.

APPLICATIONS

- Broadband
- Easy Alignement
- Modular

Thanks to its High Precision mechanics and its modular approach, the 3DOptix broadband Intensity correlator offers a modular base for autocorrelators (Figure 2 below) and cross-correlators.

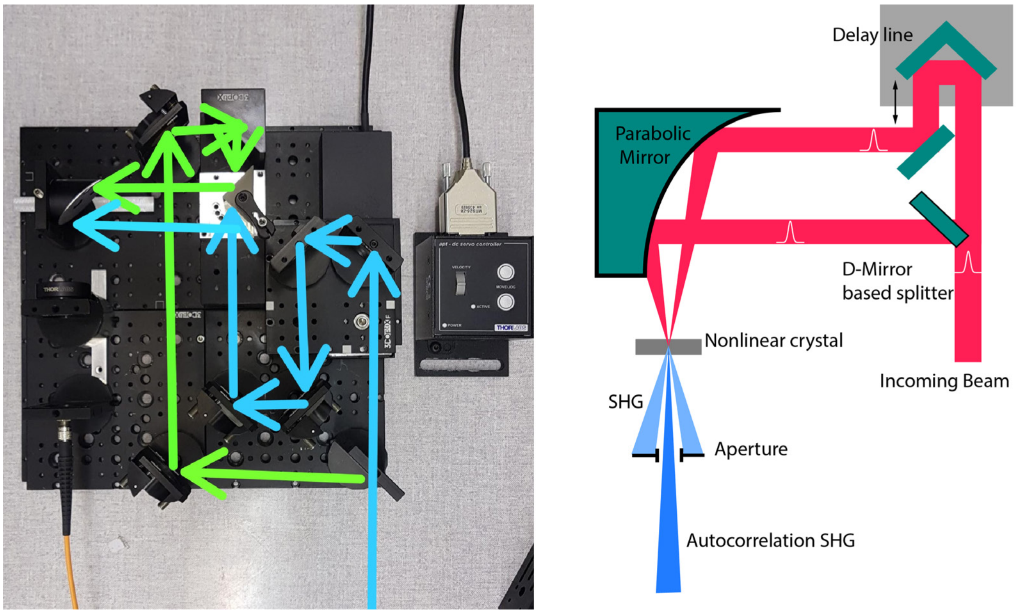

Figure 2: (left) 3DOptix Intensity autocorrelator (right) Schematic of the 3DOptix solution.

In this application, parabolic mirrors are used to cover a wide range of wavelengths from visible to mid infrared. Also, using a D-Mirror as the entrance beam splitter, the setup is readily suitable for a wide range of sources, provide the adequate nonlinear crystal is selected. Moreover, the folded configuration allows a very compact device.
The achieved design reduces the # of degrees of freedom to its minimum while providing very high accuracy on the fixed parts. This approach brings the alignment to a few minutes procedure. Thanks to the extreme robustness of the assembly – it is easy to change the optical wavelength regime of the auto-correlation. All the optical elements being refractive positioned at precise and discrete locations, it requires only the replacement of the nonlinear crystal to obtain an aligned autocorrelator in a new wavelength regime.
Also, the modularity of this 3DOptix system makes the upgrade of the apparatus to cross-correlator and FROG (Frequency-Resolved Optical Gating) immediate and straightforward. The optical paths of both of the arms remaining constant, the replacement of the nonlinear crystal and of the beam-splitter by a dichroic mirror (to separate the incoming colors) will result in a cross-correlator configuration. Moreover, replacing the single detector to a fiber-based spectrometer to collect the SHG spectrum will further upgrade the apparatus to autocorrelation based FROG configuration, ready for FROG algorithm-based measurements.