# In-situ diagnostic of ultrashort probes based on Kerr-index transient Bragg grating

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Pump-probe experiments are essential tools to investigate ultrafast dynamics of laser-matter interaction. We are particularly interested in the dynamics of transparent dielectrics under high numerical aperture focusing. Two main challenges arise for the weak probe pulse. First, we need a precise knowledge of the probe delay with respect to the pump pulse. Second, dispersion compensation of the ultrashort probe pulse generally requires a prism compressor, which can generate angular dispersion, and therefore incorrect interpretation of the pump-probe measurements.

At state of the art, pulse synchronization is performed via nonlinear frequency mixing or via a transient Kerr effect [1]. However, non-linear frequency mixing requires high intensity probe pulses, relatively long interaction range and needs to be realized ex-situ in specifically-cut optical conversion crystals [2]. Identically, synchronization using Kerr effect based optically generated anisotropy is widely used to characterize supercontinuum probes, but also requires long interaction length to obtain detectable polarization rotation.

We report on a novel technique based on a Kerr-index transient grating to both synchronize and characterize angular dispersion of weak probe signals with high sensitivity. The concept is shown in Fig. 1(a). The 800 nm, ~90 fs pump pulse is spatially shaped with a Spatial Light Modulator (SLM) as a tilted interference pattern, which induces in the transparent sample an index grating due to instantaneous Kerr effect. The frequency-doubled 400 nm probe beam is collimated (waist 10 µm) and diffracts on the transient index grating. The probe duration is ~30 fs. (The pump has been spectrally filtered and is longer than the probe). The tilt angle of the transient grating matches the Bragg condition which maximizes the diffraction efficiency. The diffracted probe signal is a cross-correlation signal that we use both to find the position of the zero-delay between pump and probe as well as providing accurate measurement of the probe pulse shape. Fig.1(b) shows the evolution of the cross-correlation signal for various positions of the prism compressor, which is used to minimize the probe pulse duration within the sample.

In addition, the images of the far-field diffracted probe enable the retrieval of the angular dispersion of the probe pulse. Figure 1(c) shows the evolution of the signal with delay and deviation angle (orthogonally to the diffraction angle) for different positions of the prisms in our prism compressor. This is particularly useful to adjust the parallelism of the prisms with angular precision of 1 mrad.

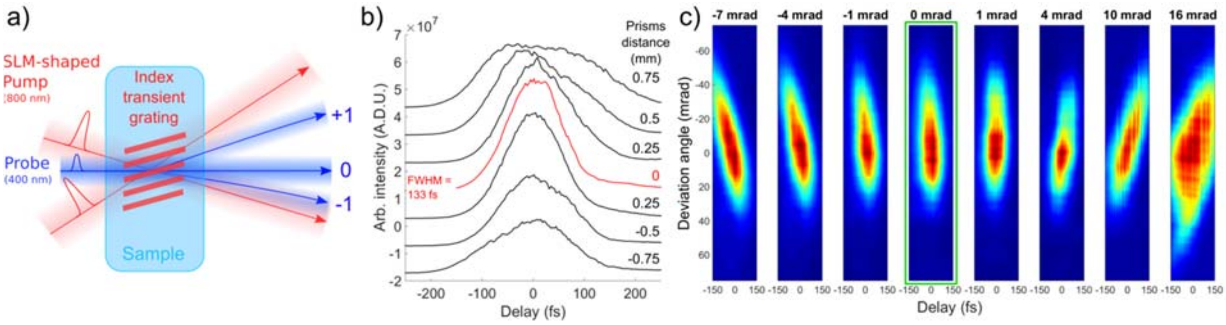


**Fig. 1** a) Transient grating schematic principle. b) Cross-correlation curve for different probe pulse compression parameters. Most compressed diffracted signal is shown in red. c) Spatial distribution of the diffracted intensity as a function of pump-probe delay for different mismatch angles from perfect parallelism in the prism compressor, highlighting the best position can be determined with accuracy better than 1 mrad.

This new technique is very sensitive, can be used for any probe wavelength, and is realized in the sample on which further pump-probe dynamics experiments will be performed. In addition, it requires a propagation distance that can be as short as a few tens of micrometers (typ. 10-30 µm), such that we could even measure the difference in group velocity between pump and probe in the sample by performing the experiment at different focusing depths. We believe this technique will find a number of applications in the field of ultrafast physics, where pump pulses are more and more shaped using Spatial Light Modulators.

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## References

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