Pulse train coherence control with time dependent spectral phase modulation

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Introduction

There is considerable interest towards the coherence properties of trains of short pulses, since pulse trains exhibiting partial coherence are generated by many real sources \cite{1}. Several analytical models have been developed to describe these pulse trains, perhaps the simplest among them being the Gaussian Schell model (GSM) \cite{2}. These models have been studied theoretically in connection to real life situations, but they have not been experimentally produced before.

Implementation

We employ a phase only spatial light modulator (SLM) to customize the correlations between different spectral components in a fully coherent pulse train \cite{3}. Our setup is depicted in Fig.1, where the input field is dispersed into its Fourier spectrum at the plane of the SLM, and a time dependent spectral phase modulation is applied to it. Subsequently, the reflected light is recombined into a collimated output beam. This allows us to control the statistical properties of the pulse train, and produce desired correlations. We measure the pulses with the frequency resolved optical gating (FROG) technique, and compute the corresponding correlation functions.

Experimental confirmation

The system illustrated in Fig. 1 has been used to demonstrate the effect of quadratic spectral phase variation, results of which are shown in Fig. 2. In this experiment, we vary the slope of the quadratic spectral phase $\phi(\omega) = \omega^2 \tau / \Omega_c$, where $\tau$ is the slope parameter that we change in a time dependent manner, and $\Omega_c$ is the coherence bandwidth. We vary $\tau$ according to a Gaussian weight function of three different widths, and by measuring individual pulses, we construct the complex degree of temporal coherence with $\gamma = \langle E^*(t_1)E(t_2) \rangle / (|E(t_1)| |E(t_2)|)$. It is clear that the varying spectral phase induces partial coherence to the almost completely coherent train that is incident on the device.

Figure 1. Femtosecond pulses incident from the right (red) are directed towards grating $G$, and lens $L$ images the Fourier spectrum at the SLM. The linear polarizer LP is used to remove unwanted polarization components from the beam and the reflected light (green) is collected with a small mirror and sent to a FROG device for measurement.

Figure 2. Experimental results when the incident pulses are modulated with a quadratic phase of varying slope. The maximum slope increases from left to right, reducing the overall degree of coherence.