

## OPTICAL PULSE COMPRESSION BY PHOTONIC DEVICES

P.A. COSTANZO-CASO<sup>†</sup>, C. CUADRADO<sup>†</sup>, R. DUCHOWICZ<sup>†</sup> and E. SICRE<sup>‡</sup>

<sup>†</sup>*Centro de Investigaciones Ópticas (CIOP), Camino Centenario y 506, La Plata (1900), Argentina.  
Facultad de Ingeniería, UNLP.*

*pcostanzo@ing.unlp.edu.ar, ricardod@ciop.unlp.edu.ar*

<sup>‡</sup>*Universidad Argentina de la Empresa (UADE), Lima 717, Buenos Aires (C1073AAO), Argentina  
esicre@uade.edu.ar*

**Abstract**— By combining phase modulation and dispersive transmission on a given time-varying input signal, we propose an optical device for producing ultrashort light pulses of high optical power. We derive the relationship between the required properties of the input signal and the device parameters in order to optimize the energy concentration in the output optical pulses. The high-order aberrations effects of the time lens which perform the phase modulation are considered. Besides, the differences on the obtained pulse shape when the input signal has a gaussian or a super-gaussian envelope are illustrated. Finally, some numerical simulations are shown which illustrate the feasibility of the method.

**Keynotes** — Optical fiber devices, Optical pulse compression.

### I. INTRODUCTION

The development of techniques for the analysis and synthesis of ultrashort optical pulses has become a subject of the most importance in the field of optical communications, photonic signal processing and ultrafast optics. From the spatial-temporal duality theory (Kolner, 1994; Papoulis, 1994, Bennett and Kolner, 2001; Van Howe and Xu, 2006) well-known concepts and experiments developed in the framework of spatial image processing can be transferred to the temporal domain thereby providing new ways for analyzing and processing temporal optical signals. Among several applications, the temporal Talbot effect (Azaña and Muriel, 2001; Azaña and Chen, 2003; Cuadrado-Laborde *et al.*, 2006; Chantada *et al.*, 2006) and others similar techniques (Torres-Company *et al.*, 2006; Komukai *et al.*, 2005) were implemented in order to produce periodic pulse trains with different repetition rates. The basic components of these temporal devices are dispersion lines, such as optical fibers (OF) or linearly chirped Bragg gratings (LCFG), and time lenses which are basically quadratic phase modulators.

In this paper, we analyze the conditions to be achieved by a photonics device combining phase modulation and dispersive transmission on a certain time-varying input signal for producing ultrashort light pulses with high optical power. Same as periodicity of the input signal assures selfimaging when the Talbot condition is satisfied, energy concentration requires a

photonic device acting on the input signal in a similar way as a spatial “diffractive” lens focuses light energy.

In Section II we derive the conditions to be fulfilled by the several parameters associated with the setup here proposed, for obtaining well conformed light pulse of high-energy. Besides, we analyze the effect on the pulse shape of the combined action of third- and fourth-order aberrations of the time lens, and the detuning from the proper dispersion value of the dispersive media. In Section III we analyze the system implementation feasibility with real devices (phase modulators and dispersive lines) and the quality of the pulses generated are discussed. In Section IV the pulse generation is analyzed by considering a laser source where the envelope of the emitted signal is a gaussian or a super-gaussian function. Finally, in Section V we present the conclusions of this work.

### II BASIC THEORY

Let us consider that the input signal to the system to be analyzed is given by the output of either a continuous (CW) or a pulsed laser centered at the angular frequency  $\omega_0$ , but modulated with a signal that has a linear frequency variation. Thus, its complex envelope can be written in a general form as

$$X_m(t) = A(t) \exp(-i C t^2 / 2 T_0^2) \quad , \quad (1)$$

where we denote as  $A(t)$  the baseband amplitude (continuous or pulsed) of the input signal,  $T_0$  is related with the temporal duration of  $X_m(t)$ , and  $C$  is a chirp parameter which takes into account a linear frequency variation. This input signal is successively phase modulated by a temporal lens and transmitted through a first-order dispersion line for producing the output signal  $X_{out}(t)$ . The phase function associated with the optical modulator can be written as  $\phi(t) = \phi_{20} t^2 / 2 + \Delta\phi(t)$ , where  $\phi_{20}$  is the quadratic modulation factor responsible of the lens action and  $\Delta\phi(t)$  is the deviation term (which includes higher orders terms in the Taylor expansion of  $\phi(t)$ ) which can be treated in a similar way as the aberration function is analyzed in spatial imaging. Regarding with the dispersion line, it has associated a quadratic-phase spectral response centered at the mean frequency  $\omega_0$  of the input signal, with a second order parameter  $\Phi_{20}$ . For arbitrary values of the device parameters  $\phi_{20}$  and  $\Phi_{20}$ , the baseband equivalent amplitude of the output signal becomes