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# Time- and spectral-domain holography for high-speed processing of optical signals

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## Abstract

The ever-increasing traffic data requirements in telecommunication services lead to a continuous need for higher transmission capabilities. Fiber-optics communications have proven to be a very promising way of achieving such high bitrates. Nowadays, the combination of wavelength division multiplexing (WDM) techniques and coherent technologies enables a more efficient use of the available spectrum, but it also hinders the required circuitry in the transmitter, receiver and intermediate networks nodes. WDM requires opto-electronic signal conversion circuits individually set and operated for each different wavelength channel. Besides, with the employment of high-order complex (amplitude and phase) modulation formats, the optical in-phase and quadrature (IQ) components of the information signal need to be generated, processed and detected independently, additionally requiring proper synchronization of these two IQ optical paths.

The problem of simultaneously controlling the amplitude and phase of a complex-envelope optical signal has been long overdue in spatial-domain systems. Holographic techniques allow the detection, reconstruction and processing of complex-valued information signals through the use of intensity-only sensitive components. Inspired in this concept, we introduce new signal processing techniques that remarkably simplify the required electro-optical circuitry (and consequently the power consumption) in coherent optical systems. Furthermore, we also develop new ultrafast all-optical signal processors, able to process the information directly in the optical domain at ultrafast speeds (into the THz regime).

In this talk, we first introduce the exact time-domain counterpart of spatial domain holography, by means of the space-time duality. This novel method enables simultaneous control of the amplitude and phase of a complex temporal optical waveform using a simple setup composed of devices sensitive to intensity-only variations. Then, using the Fourier-transform property of duality between the time domain and the frequency domain, we also propose and formulate the concept of spectral-domain holography. This concept enables the simultaneous control of the amplitude and phase of an optical spectral response by just manipulating the amplitude spectrum. Finally, several applications of time-domain holography and spectral-domain holography are presented, validating the versatility of the introduced concepts. In fact, considering the broad range of applications of classical holography, we can foresee a similarly vast number of interesting uses for its time/spectral-domain counterpart.

## Bio

María R. Fernández Ruiz received the B.S. degree in telecommunication engineering (five-year engineering program) and the M.S. degree in electronic systems and signal processing from the Universidad de Sevilla, Spain, in 2009 and 2011, respectively. She is currently with the Ultrafast Optical Processing group at the Institut National de la Recherche Scientifique-Énergie, Matériaux et Télécommunications (INRS-EMT)-Université du Québec, (Montréal, Canada), working under the supervision of Prof. José Azaña and Prof. Alejandro Carballar.

Her recent research interests include ultrafast signal processing devices, fiber/waveguide Bragg gratings, microwave photonics, nonlinear optics, programmable and reconfigurable devices for optical computing, optical sensors, photonic integrated circuits, space-time duality and holography.

María R. Fernández-Ruiz is a student member of the OSA and SPIE.

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