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Congratulations to New ICFO PhD Graduate

Dr. Daniel Urrego graduated with a thesis entitled ?Demonstration of new experimental schemes for imaging and sensing: from quantum to classical and back'

November 14, 2023

We congratulate Dr. Daniel Urrego who defended his thesis today in ICFO's Auditorium. Dr. Daniel Urrego obtained his MSc in Physics at Universidad de los Andes in Colombia. He joined the Quantum Engineering of Light research group at ICFO led by Prof. Dr. Juan Perez Torres as a PhD student. Dr. Urrego's thesis entitled ?Demonstration of new experimental schemes for imaging and sensing: from quantum to classical and back' was supervised by Prof. Dr. Juan Perez Torres.

ABSTRACT:

This Ph.D. thesis presents research in imaging and optical sensing, exploring novel concepts, and diverse applications. The experimental schemes put forward here are based on simulating specific aspects of quantum concepts using classical Optics. The last scheme takes the opposite direction. Employing quantum techniques, it develops the quantum version of a Differential Interference Contrast (DIC) microscope. The thesis is divided into several chapters, each addressing distinct aspects of an experimental scheme and its potential applications.

The first scheme introduces a proof-of-concept demonstration of an optical gate that uses light beam with orbital angular momentum. Inspired by the quantum fingerprinting protocol, this gate enables the efficient comparison of data strings and waveforms without the need for signal disclosure. The gate is tested comparing string of bits, strings of quarts and different waveforms.

The second scheme presents a protocol to assess the presence of a particular spatial shape (or waveform) in a database, by evaluating the degree of similarity between the unknown spatial shape with all the elements contained in the database. The protocol is tested by comparing the shape of a trimmed disk in a database. The protocol is extended to the temporal domain, where the shapes are encoded in the amplitude of the electric fields.

The third scheme is a novel approach to do Optical Coherence Tomography (OCT) with a

fully non-mechanical scan. By leveraging the principles of spectral domain OCT and integrating a spatial light modulator (SLM) into the setup, non-mechanical steering of the illumination optical beam is achieved. This innovation eliminates the necessity of transverse scans using mechanical platforms potentially boosting the enhancement of the size, weight, and power (SWaP) of future commercial products.
The last scheme is a quantum version of the Differential Interference Contrast (DIC) microscope, harnessing the remarkable Hong-Ou-Mandel (HOM) effect to retrieve phase gradients induced by varying optical thickness. In this case, the knowledge of quantum optics is applied to a microscope technique.
The work presented in this thesis contributes to the idea of using protocols from the quantum world that could be mimicked in classical applications.

Thesis Committee:

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