ICFO

PhD Thesis Defense: Photons and Information - A modern approach to strong-field quantum optics

PHILIPP STAMMER

June 09, 2026

10:00

ICFO Auditorium

Photons and Information are notions indispensable for modern quantum technologies, and their interplay provides the foundation of understanding the quantum nature of light. In particular, photons are robust information carrier and substantiate the inherent discreteness of the electromagnetic radiation field. The information of photons, and their intrinsic quantum fluctuations, are manifested in the measurement of correlation functions of the field. Central to the understanding of photon fluctuations is the quantum theory of optical coherence, and the photon signature can reveal itself in different properties. Furthermore, the measurement of correlations is needed from an information theoretic perspective to distinguish classical from quantum signatures. These concepts ultimately lead to the original goal of the present Thesis:

How can we understand the notion of photons and information in a modern strong field quantum optics perspective?

Strong field quantum optics aims for the generation, characterization and the control of quantum light, beyond the conventional wisdom of strong field physics. In the traditional approach to strong field phenomena, in particular the photon up-conversion process of high-order harmonic generation, the field was merely treated classically. And hence, the notion of the photon could not exist in such descriptions. However, recent advances in the field of strong field quantum optics have revealed new signatures unaccountable by classical theory. This includes the generation of genuine non-classical states of light from strong field phenomena, revealing the intrinsic entanglement between all field modes in the process of high-order harmonic generation, or finding quantum signatures in the photon emission process itself via photon anti-bunching. In this Thesis, we reveal all such properties of the generated light field, and establish the underlying theories for the description of these phenomena. This includes the development of the quantum theory of optical coherence for high-order harmonic generation, as well as introducing new quantum information theoretic perspectives to strong field quantum optics. Therefore, the work presented in this Thesis provides the foundation for the modern formulation of quantum optical phenomena in strong field physics.

Thesis Director: Prof. Dr. Maciej Lewenstein

Hosted by: Academic Affairs