Ecole Doctorale 352

Physique et Sciences de la Matière

Sujet de thèse

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Titre : **2 photon correlations: from fundamentals to applications.**

Description :

The Nobel prize 2022 crowned the work realized by Alain Aspect on entangled photon pairs more than 40 years ago. Here we propose (part A, fundamental*) to investigate the deep nature of these correlations in relation with the possible existence of so-called empty waves and (part B, applied**) to exploit the correlations in time of pairs of photons resulting from a biexcitonic or cascade process in order to improve fluorimetric metrology.

(A) Roughly summarized, if empty waves possess a physical reality and that they belong to 3D space (and not to the configuration space, 6D in the case of photon pairs), even after detecting one photon, its empty wave can influence the other photon, a measurable effect that could be revealed by performing well-thought correlation measurements. If this effect gets confirmed by experiments it could lead to a substantial increase of the transmission length with potential applications in quantum cryptography and communication.

*Does the influence of empty wave survive in configuration space? T. Durt, Foundations of Physics 53 (1), 1-24.

(B) When pairs of photons of frequencies f1/f2 are emitted by an individual fluorophore in a short lapse of time T, superposed to a continuous background noise, the signal/noise ratio associated to their joint detection is equal to C12.T/(S1.T.S2.T) with C the non-accidental coincidence rate, and S1/2 the rate of single detections at frequencies f1/f2. It increases proportionally to the inverse of T which can become very large for small values of T. This technique is promising regarding metrological performances of conventional fluorimetry, in the case of low counting rates, with potential applications in tracing and marking.

**Fluorimetry in the Strong-Coupling Regime: From a Fundamental Perspective to Engineering New Tools for Tracing and Marking Materials and Objects, M .Hatifi, D. Mara, B. Bokic, R. Van Deun, B. Stout, E. Lassalle, B. Kolaric, T. Durt, Applied Sciences 12 (18), 9238.