THEORY LECTURE: ATTOQUIS - Connecting Attoscience and Quantum Information

Quantum Optics Theory group

May 03, 2022 to May 24, 2022

10:00 to 12:00

BLR

In the set of 4 lectures we will discuss perspective of merging ideas from attoscience (AS) and ultrafast physics (UP) with quantum information and quantum technologies. We will in fact focus on ATTOQUIS, the new joint project of ICFO, FORTH, Technion, CEA, and IOTA toward a symbiosis of attoscience (AS) and quantum information (QI). This is in particular aimed at studying the generation of entangled/quantum correlated states using conditioning methods. I will describe our joint efforts to generate Schrodinger cat states (SCS) of photons conditioned on high harmonic generation (HHG) and/or above threshold ionization. We will also talk about generation of topological order using laser pulses with orbital angular momentum (OAM). We will also discuss HHG as a tool to detect phase transitions and topological in strongly correlated systems. If time permits, we will speculate about measurement of entanglement of OAM of electrons in double ionization, and violation of Bell inequalities by SCS states.

Contemporary Quantum Technologies face major difficulties in fault tolerant quantum computing with error correction, and focus instead on various shades of quantum simulation (Noisy Intermediate Scale Quantum, NISQ) devices \cite{Preskill18}, analogue and digital Quantum Simulators \cite{GAN14} and quantum annealers \cite{FFG01}. There is a clear need and quest for such systems that, without necessarily simulating quantum dynamics of some physical systems, can generate massive, controllable, robust, entanglement and superpositions states. This will in particular allow the use of decoherence in a controlled manner, enabling the use of these states for quantum communications \cite{GT07} (e.g. to achieve efficient transfer of information in a safer and quicker way), quantum metrology \cite{GLM11}, sensing and diagnostics \cite{DRC17} (e.g. to precisely measure phase shifts of light fields, or to diagnose quantum materials).

In the ATTOQUIS project, we propose an answer to these needs, by opening new avenues for QI science in symbiosis with Atto-science (AS) and Quantum Optics (QO). To date, there are no existing platforms that can bring processes at such short time-scales to Quantum Information systems. ATTOQUIS aims at realizing a universal and firmly established tool to offer completely unknown solutions and developments, i.e. set of stable and reproducible methods to generate massive entangled states and massive quantum superpositions. This

project will apply them in Quantum Information science, but with the final goal of bringin them to Quantum Technologies (QT). This will be accomplished by: i) Studying th generation of entangled/quantum correlated states using conditioning methods; ii) Studyin strong-field physics and atto-second science driven by quantum light; iii) Studyi g quantitative and measurable effects of decoherence in atto-scienc

Days: May 3rd, 10th, 17th & 24th
May 3th - Introduction to Atto-science by Prof. Dr. Maciej Lewenstein
May 10th - Generating entanglement in AS (I) - Introduction to QED of AS by Phili p Stammer and Javier Dean
May 17th - Generating entanglement in AS (II) - Conditioning methods; other phenomena b Philipp Stammer and Javier Dean
May 24th - Ultrafast physics of strongly correlated systems and topological order by Dr. Tobias Grass and Dr. Utso Bhattacharya
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