INTERNSHIP PROPOSAL

Laboratory name: European Center for Quantum Sciences / Institut de Science et d'Ingénierie Supramoléculaires
CNRS identification code: UMR 7006
Internship supervisor's surname: Tom Bienaimé
e-mail: t.bienaime@unistra.fr Phone number: 03 68 85 51 71
Web page: eqm.cesq.fr
Internship location: University of Strasbourg, France

Thesis possibility after internship: YES
Funding: YES, either through an application to the Doctoral School or through a research grant, depending on the outcome of funding applications currently under evaluation.

Single-Photon Detection and Correlation Measurements in Ultracold Atoms

The Exotic Quantum Matter (EQM) Group is looking for a highly motivated Master 2 student to characterize a single-photon detection system that will subsequently be integrated into the experimental platform. The EQM group operates a quantum simulator based on ultracold potassium atoms to study strongly interacting quantum matter and light–matter interactions.

The EQM team has already demonstrated strong photon–photon interactions through classical measurements of optical intensity and phase. The next step is to investigate these interactions at the level of individual photons, where quantum correlations become directly accessible.

The internship will establish a two-channel single-photon detection system based on two single-photon avalanche diodes (SPADs) and a high-resolution photon arrival-time tagger. The system will be used to measure the second-order photon correlation function $g^2(\tau)$.

OBJECTIVES

The student will:

• Characterize the SPADs and time tagger, including dark counts, detection efficiency, dead time, afterpulsing, timing resolution, coincidence rates, and long-term stability.

• Measure $g^2(\tau)$ for a strongly attenuated laser in a Hanbury Brown–Twiss setup. For coherent light, $g^2(\tau) \simeq 1$.

• Measure $g^2(\tau)$ for thermal light and observe photon bunching, with $g^2(0) > 1$, ideally approaching $g^2(0) = 2$. If feasible, the student will independently measure $g^1(\tau)$ and test the Siegert relation: $g^2(\tau) = 1 + |g^1(\tau)|^2$.

• Measure $g^2(\tau)$ of light scattered from a cold atomic cloud, resolve the two characteristic timescales of single and multiple scattering, and study their dependence on temperature and optical thickness.

These experiments will validate the detection system, demonstrate its ability to resolve coherent and thermal photon statistics, and provide a tool for studying temporal correlations and light scattering in cold atomic clouds. The student will acquire hands-on experience in experimental quantum optics, single-photon detection, photon-correlation measurements, optical instrumentation, and data analysis.

PERSPECTIVES

This internship can provide a natural starting point for a PhD thesis within the EQM group. The first stage would involve integrating the detection system into the ultracold potassium experiment to study photon correlations generated through Rydberg electromagnetically induced transparency. The goal will be to investigate Rydberg-mediated photon–photon interactions through measurements of photon bunching and antibunching. The techniques developed could subsequently be extended to multimode experiments, enabling the study of spatial and temporal correlations between several optical modes.