INTERNSHIP PROPOSAL

Laboratory name: **Laboratoire Kastler Brossel – Quantum Networks Team**
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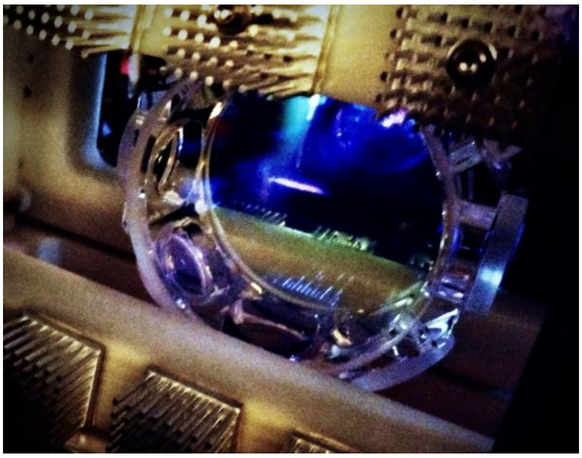
Thesis possibility after internship: YES
Funding: YES, Doctoral school/group funding

Quantum-repeater architecture with high-performance optical memories



In the broad context of quantum communications, one stream of research aims at creating a so-called Quantum Internet. Among other applications, ranging from extending the baseline of telescopes to clock synchronization and sensor networks, the creation of a Quantum Internet would enable long-distance quantum information transfer. Central to this endeavor is the concept of **quantum repeater**. It consists in dividing a long communication channel into various shorter segments over which entanglement can be faithfully distributed. Adjacent segments are then connected by entanglement swapping operations. To be scalable, this approach requires **quantum memories**, which enable quantum states to be stored at each intermediate node.

In this context, the **LKB team developed a large cold atomic ensemble based on an elongated magneto-optical trap (3-cm long)**, enabling to obtain a large optical depth (above 500). Using this setup, in 2018, the team demonstrated qubit storage with an overall efficiency close to 70%, a value that doubled the usual performances at that time. Recently, **the team pushed this value even higher and reached the 90% mark for entanglement storage between two memories**. **This is the state-of-the-art** in term of storage-and-retrieval efficiency for a quantum memory, regardless of the physical platform considered.

The work is now focusing on two directions. A first one is to improve other figures of merit, including storage lifetime and multimode capacity. A second one is the demonstration of a **50-km telecom quantum repeater link relying on two distant quantum memories and frequency non-degenerate photon pair sources.** These efforts enter into the context of the French Initiative on Quantum Information, including the Paris Region quantum testbed where memories can be deployed, and the European Flagship project "Quantum Internet Alliance" that aims at developing a pan-European quantum internet. Part of the work will be led in collaboration with the startup company Welinq.

A few references:
Efficient reversible entanglement transfer between light and quantum memories, Optica 7, 1440 (2020)
See also the story about this work in IEEE spectrum: Quantum memory milestone boosts quantum internet future
Highly-efficient quantum memory for polarization qubits in a spatially-multiplexed cold atomic ensemble, Nature Communications 9, 363 (2018)

Condensed Matter Physics:	YES	Soft Matter and Biological Physics:	NO
Quantum Physics:	YES	Theoretical Physics:	NO