Consortium

Universities and Research Institutes:

Coordinator: Consiglio Nazionale delle Ricerche (CNR – Italy)

Eidgenössische Technische Hochschule Zürich (ETH – Switzerland)

Technische Universität München (TUM – Germany)

Centre National de la Recherche Scientifique (CNRS – France)

Agenzia Spaziale Italiana (ASI – Italy)

Companies:

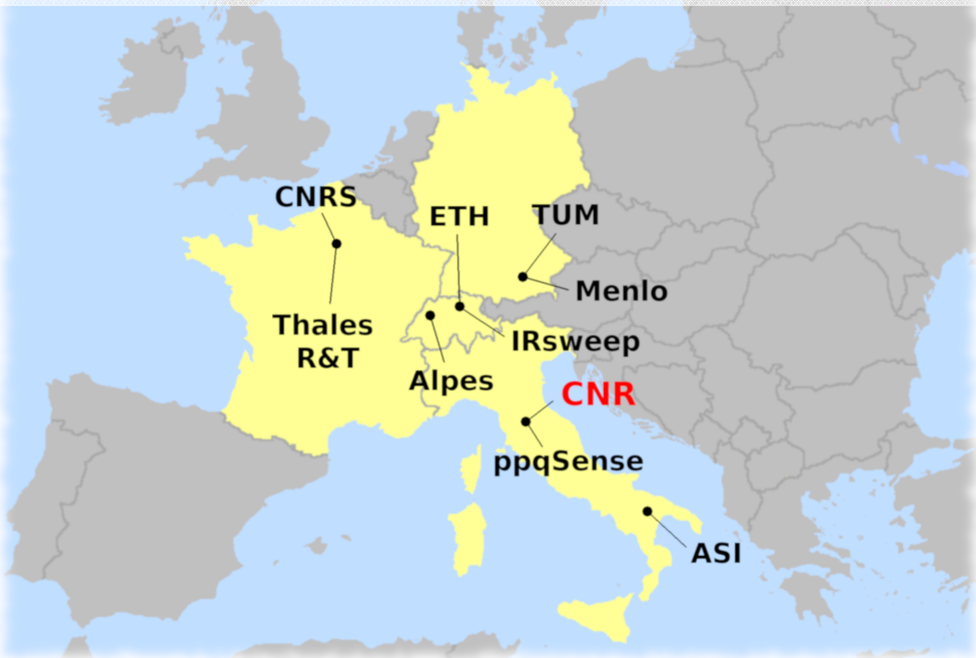
Alpes Lasers (Switzerland)

IRsweep (Switzerland)

ppqSense (Italy)

Menlo Systems (Germany)

Thales Research & Technology (France)



QUANTUM FLAGSHIP

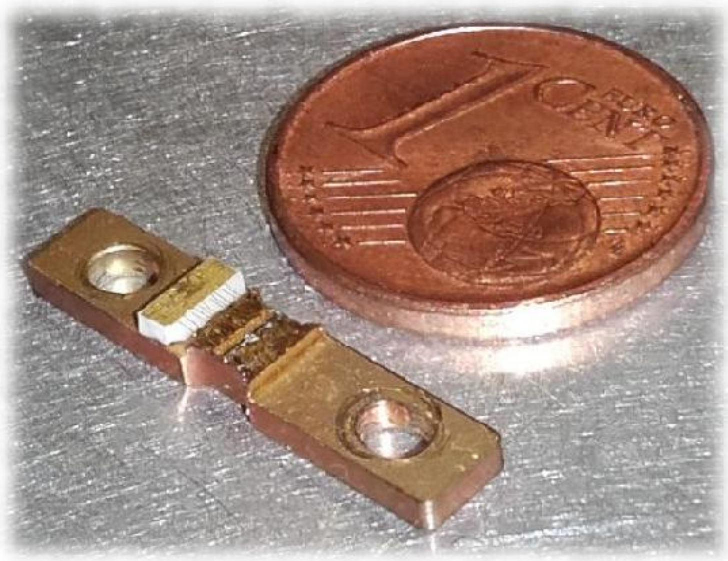
Qombs

Coordinator:

Augusto Smerzi

December 2019

Project focus: quantum cascade lasers



The main goal of the Qombs Project is the **"quantum optimization"** of quantum cascade lasers and in particular of quantum cascade laser frequency combs.

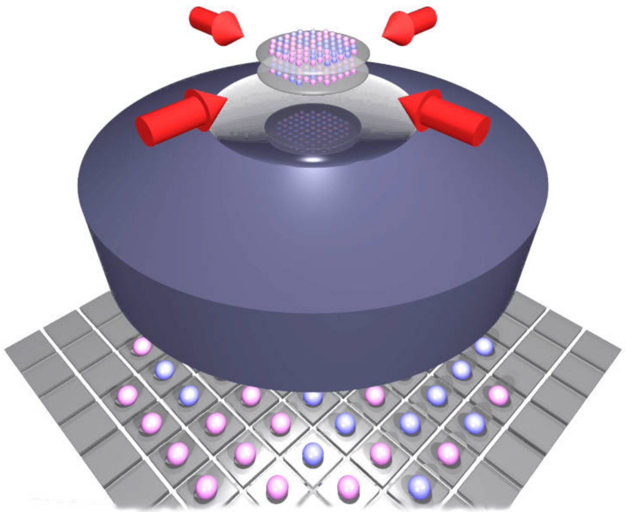
QCLs are heterostructured semiconductor lasers operating in the mid and far infrared able to generate frequency combs.

The **carrier transport** quantum dynamics in the semiconductor etherostructure and the possible **emission of non-classical light states** have not been investigated so far.

Goals: - Deliver **a new generation of QCLs and QCL-combs** able to emit squeezed light with entanglement among the modes.

- Demonstrate the possibility of quantum simulate the main dynamics proper of a **real device**.

Implementation & applications



The **carrier transport** will be simulated by means of a gas of ultracold fermions trapped in an optical lattice.

From the simulation we expect to gain information enabling the optimization of laser operation.

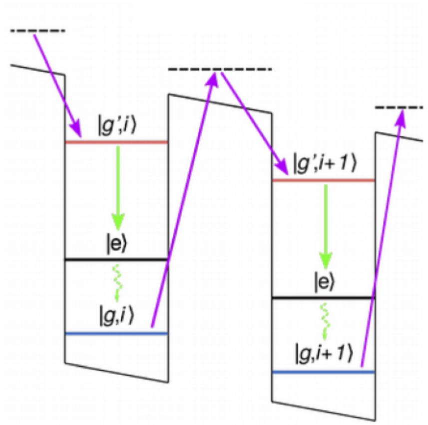
The **emission of multimode non-classical states** will be investigated by means of advanced techniques, highly innovative in the infrared spectral region.

The successful realization of the Qombs project will provide a **quantum device** useful for **advanced (secure) free-space communication**, high-sensitivity **detection of pollutants** and **health monitoring**.

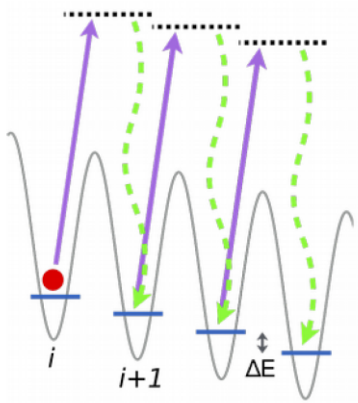
Quantum simulation with fermions

Fermions are used to simulete carrier transport within QCL active region.

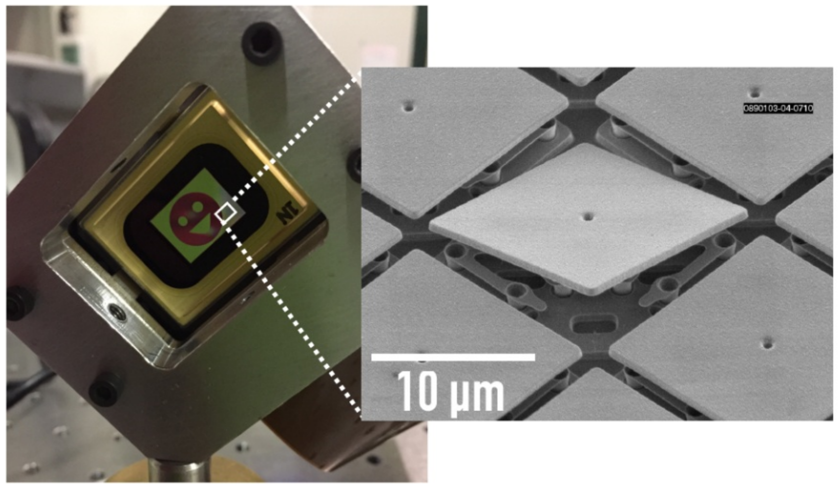
QCL



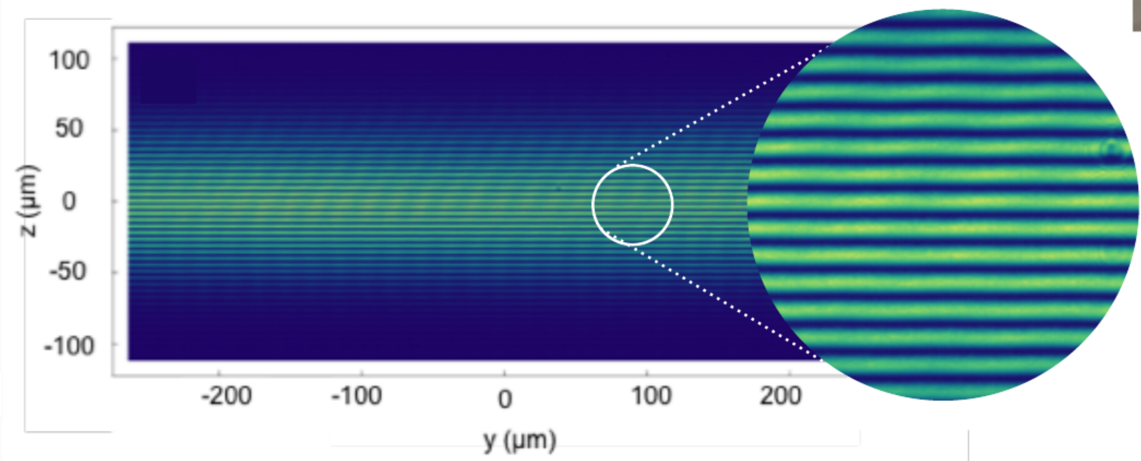
optical lattice



Digital Micromirror Device (DMD)



Large-spacing lattice: d ~ 5µm

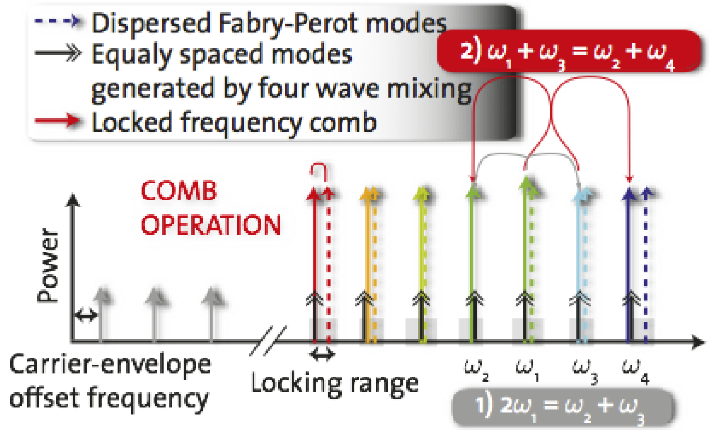


At the moment the optical lattice has been realized, the loading of the atoms in under optimization.

Quantum simulation with bosons

Bosons are used to simulete photon non-linear interaction within QCL waveguide.

QCL-comb



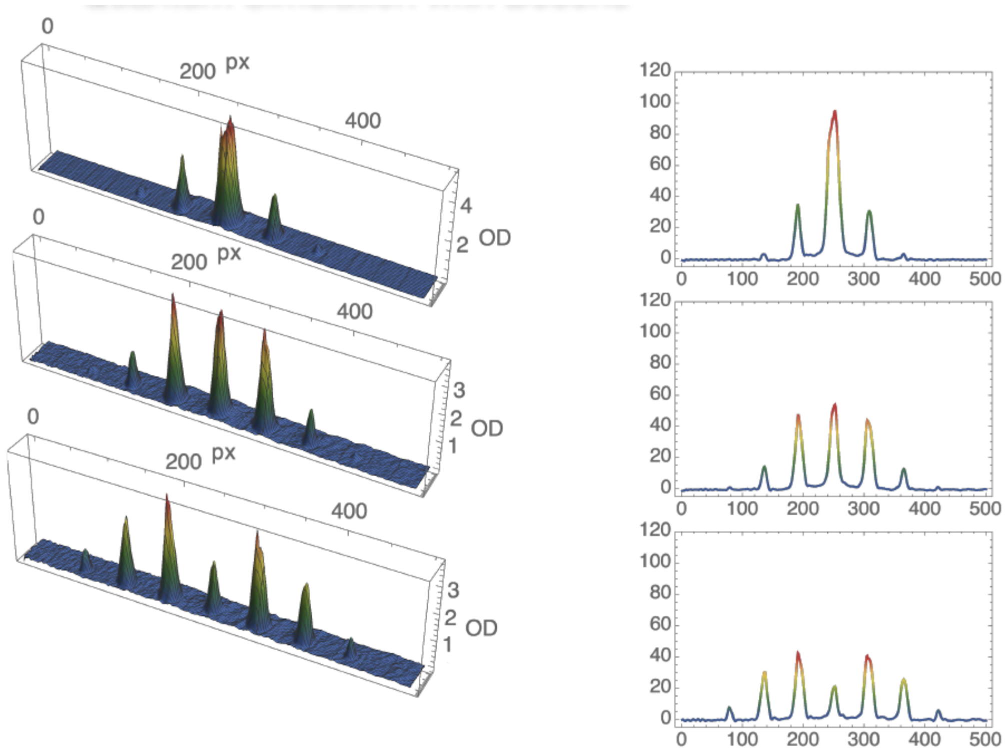
$P = 105mW$

$t_{pulse} = 4\mu s$

$t_{pulse} = 8\mu s$

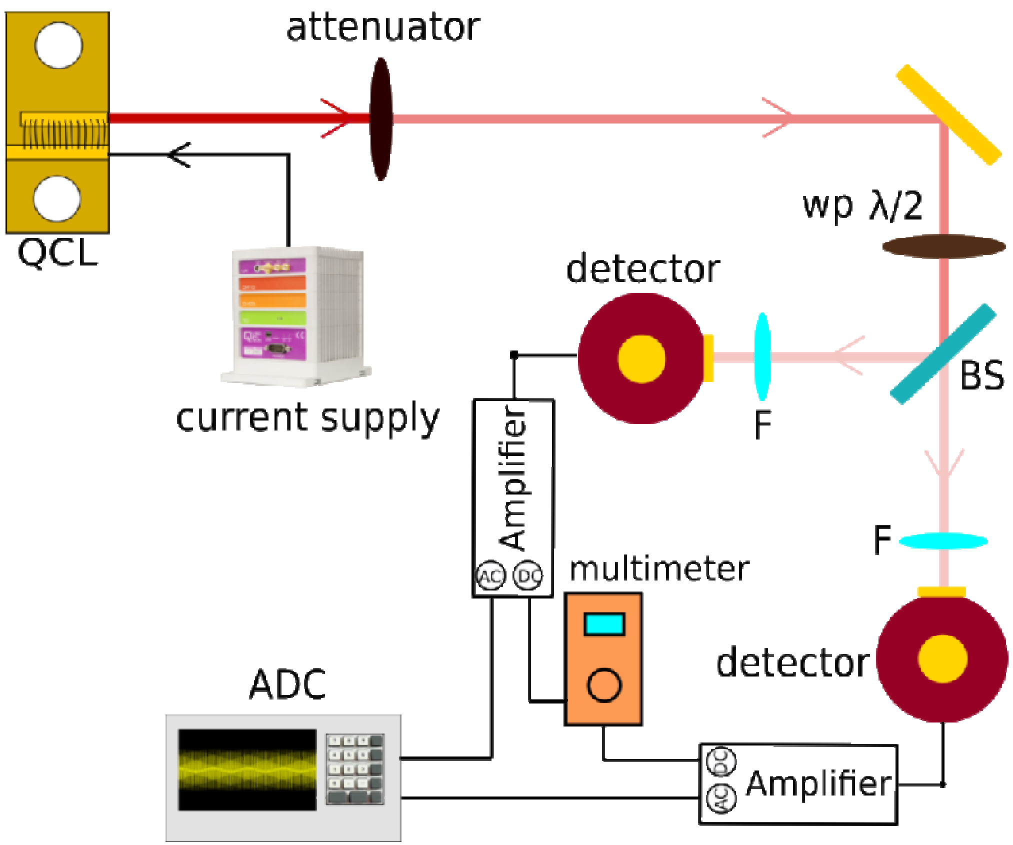
$t_{pulse} = 10\mu s$

Bosons momentum states



Quantum optical characterization

In the meanwhile a quantum optical characterization of already-available QCL-comb devices is ongoing, with the aim of identifying critical aspects and detection limitis of a mid-infrared homodyne and second-order correlation setup.



At the moment the main limiting factor is the low quantum efficiency characterizing commercial mid-infrared detectors.