# Internship Proposal

**Laboratory name:** MPQ (Matériaux et Phénomènes Quantiques)
**CNRS identification code:** UMR7162
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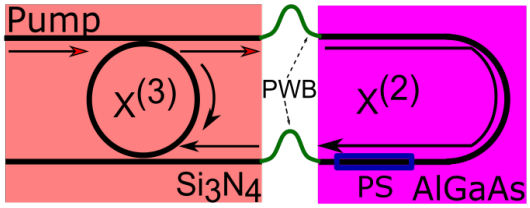
**Internship location:** Bât. Condorcet – 10 Rue A. Domon et L. Duquet – 75013 PARIS\

**Thesis possibility after internship?** Yes
**Funding?** YES (ANR-DFG QuadComb Project, co-funding from DGA)

## Optical microcombs exploiting both $\chi^{(2)}$ and $\chi^{(3)}$ nonlinearities

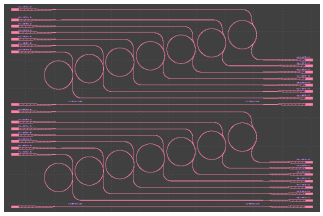
**Scientific project:** High-contrast microrings combine high Q factors and small cross section, allowing for strong nonlinear light-matter interaction at low optical power and group-velocity-dispersion management. Such cavities are used in an increasing set of photonic applications like microlasers, parametric oscillation, and optical frequency comb (OFC) generation.

Over the last years, so-called Kerr OFCs, generated in high-Q microresonators with cubic nonlinearities, have raised significant interest. These devices offer broadband spectra with uniform line powers and free spectral ranges of tens or hundreds of GHz, while being fully amenable to chip-scale integration. Kerr "microcombs" thus open the potential to disrupt a series of highly relevant applications, ranging from massively parallel wavelength-division multiplexing in optical communications to high-precision optical ranging and high-resolution spectroscopy. Despite this potential, full deployment of Kerr combs is still hindered by stability and uniformity issues, plus limited spectral spanning. In addition, efficient schemes for controlling the carrier-envelope offset frequency of Kerr combs are still lacking, thereby impeding the application of Kerr combs in high-precision optical metrology and optical frequency standards.




Scheme of hybrid microcomb based on frequency doubling of the generated Kerr comb in a $\chi^{(2)}$ AlGaAs-on-insulator photonic integrated circuit. The frequency-doubled comb is fed back to the high-Q $\chi^{(3)}$ micro-resonator for injection locking and self-referencing of the generated Kerr comb. (PS: phase

In this internship, by combining Kerr-type cubic with quadratic optical nonlinearities, we will explore and implement novel approaches for OFC generation in photonic integrated circuits, which enable a richer nonlinear dynamics and stabilized carrier-envelope offset frequency. We'll consider hybrid device concepts, where cubic and quadratic optical nonlinearities are first realized on distinct integration platforms and then merged on a package-level by 3D-printed chip-chip connections (photonic wire bonding). This internship will take place in the framework of an already funded French-German project, in close collaboration with C2N and KIT in Karlsruhe, plus La Sapienza University in Rome. It includes the perspective of a subsequent PhD, which will rely on the promising results of our first three years of research in this exciting domain.



E-beam lithography mask realized by Luca Lovisolo for the fabrication and test of AlGaAs-on-insulator microrings.

**Methods and techniques:** Experimental nanophotonics combined with either advanced integrated optics modelling or nanofabrication, according to the skills and tastes of a brilliant and motivated M2 intern.