

Two PhD Positions in Ring Quantum Cascade Lasers (QCLs)

Experimental characterization and theoretical modelling of noise and frequency comb dynamics

The mid-infrared (MIR) is an important spectral region for many applications, including telecommunications, fundamental physics, or spectroscopy. Many of these fields require low-noise lasers to enhance performance or even to enable specific measurements. Low-noise MIR lasers nevertheless remain scarce and typically rely on bulky, complex, and expensive frequency-converted near-infrared (NIR) laser systems. On the other hand, QCLs have emerged as highly attractive MIR sources [1], but compared with state-of-the-art NIR lasers, QCLs generally exhibit significantly higher frequency noise and broader optical linewidths.

In 2023, a new type of QCL based on a ring resonator architecture was demonstrated [2]. At the Time-Frequency Laboratory (LTF) at the University of Neuchâtel, in collaboration with ETH Zurich, we demonstrated that these devices exhibit a free-running single-frequency mode linewidth approximately six times narrower than that of state-of-the-art QCLs [3]. Several fundamental questions nevertheless remain open, particularly concerning the noise mechanisms, linewidth properties, and mutual coherence of the modes when these lasers operate as frequency combs.

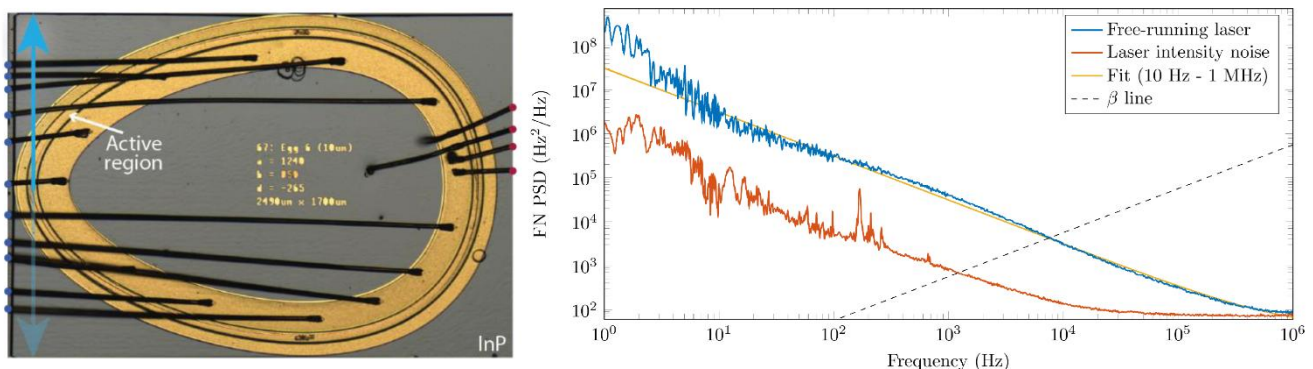


Figure 1 - (Left) Photograph of a ring QCL [2]. (Right) Frequency-noise measurement of a ring QCL operating in a single-frequency mode [3].

References

- [1] J. Faist et al. *Quantum Cascade Laser*, **Science** 264, 5158 (1994)
- [2] I. Heckelmann et al. *Quantum Walk Comb in a Fast Gain Laser*, **Science** 382, 6669 (2023)
- [3] A. Parriaux et al. *Free-running ring quantum cascade laser with 50 kHz linewidth*, **J. Phys. Photonics** 8, 025052 (2026)

Position overview

The LTF conducts research in ultrafast laser sources, optical coatings, frequency combs, nonlinear optical systems, and high-power lasers. For more than two decades, the laboratory has also investigated the characterization and stabilization of QCLs in close collaboration with ETH Zurich.

Within a recently funded SNSF project led by Dr Alexandre Parriaux, we are seeking **two PhD candidates, one focusing on experimental research and one on theoretical modelling**, to investigate the fundamental noise limits of QCL frequency combs, with particular emphasis on novel ring-resonator architectures.

- **Experimental PhD position: advanced characterization of QCL noise and coherence**

The successful candidate will develop a versatile optical platform for high-resolution heterodyne characterization of QCLs. The work will include the development of a tailored NIR frequency comb system, its frequency conversion to the MIR, and its application to measurements of frequency noise, linewidth, and comb coherence. The candidate will subsequently use this platform to investigate different QCL architectures and develop dedicated experimental setups for selected QCL-based applications such as dual-comb interferometry.

- **Theoretical PhD position: modelling of noise and frequency comb dynamics in ring QCLs**

The successful candidate will develop a theoretical framework describing frequency noise, optical linewidth, and comb coherence in QCLs, with particular emphasis on the influence of cavity geometry in ring-resonator architectures. The work will combine analytical modelling and numerical simulations to investigate noise-generation mechanisms and stabilization strategies. The candidate will also contribute to the modelling of selected QCL-based experimental systems and participate in targeted experiments designed to test and validate theoretical predictions.

General information

The two PhD candidates will work in close collaboration, with experimental results informing the theoretical models and theoretical predictions guiding the experimental investigations.

Both candidates will be supervised by Dr Alexandre Parriaux, with scientific support from a postdoctoral researcher involved in the project. They will also work in close collaboration with other researchers at the LTF and ETH Zurich.

Both PhD candidates will also be expected to publish their research findings in peer-reviewed journals, present their work at national and international conferences, contribute to scientific collaborations, and prepare periodic progress reports for the project.

Position details

- **Expected starting date:** January 1st, 2027
- **Duration:** Four years
- **Location:** Neuchâtel, Switzerland. The positions will involve occasional research visits to collaborating laboratories in Switzerland and elsewhere in Europe, as well as participation in national and international conferences
- **Environment:** Neuchâtel is in the French-speaking part of Switzerland, between Lake Neuchâtel and the Jura Mountains, offering an ideal setting for both outdoor and city activities
- **Teaching:** The positions include limited teaching duties at the university
- **Salary:** 50 000-55 000 CHF gross per year, according to the applicable SNSF salary scale

Information and requirements

- Master's degree in physics, photonics, electrical engineering, or a closely related field
- Strong motivation to conduct research in laser physics and photonics
- Ability to work both independently and collaboratively
- Good written and spoken English; knowledge of French is an advantage but not mandatory
- Basic programming skills, for example in Python or MATLAB
- **Specific requirements for the experimental position**
 - Experience or strong interest in experimental optics, laser systems, nonlinear optics, optoelectronics, or optical frequency comb technologies
 - Motivation to conduct hands-on experimental work, including optical setup development, laboratory automation, data acquisition, and precision measurements
- **Specific requirements for the theoretical position**
 - Background or strong interest in laser physics, nonlinear dynamics, and noise processes in optical systems
 - Experience with numerical methods, scientific programming, and the numerical simulation of physical systems
 - Experience in analytical modelling or the simulation of photonic systems would be an advantage

Application

Interested candidates should submit the following:

- Curriculum vitae
- Motivation letter (maximum one page)
- Bachelor's and Master's degree transcripts
- Brief summary of the master's thesis or a significant research internship, maximum one page
- Contact details of at least two academic or professional references (recommendation letters are welcome)

Please send your application to [secretariat.physique at unine.ch](mailto:secretariat.physique@unine.ch) with the subject line "PhD Application QCL – Experimental" or "PhD Application QCL – Theoretical", according to the position for which you are applying. Candidates interested in both positions may indicate this in their motivation letter.

Applications received by October 31, 2026, will receive full consideration. The review of applications will continue until both positions are filled. Online interviews are expected to take place mid-November 2026.

<https://www.unine.ch/physique/l-institut/>