Master 2 Internship and PhD Thesis 2027-2028

Molecular vibrations as room-temperature quantum oscillators

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Micro- and nanomechanical resonators are a key resource for quantum technologies, but they usually need heavy cryostats to protect them from thermal noise. Molecular vibrations are naturally protected by their very high frequencies (tens of terahertz), which makes them ideal for quantum optomechanics at room temperature. The goal of the project is to address and control these resonators with light.

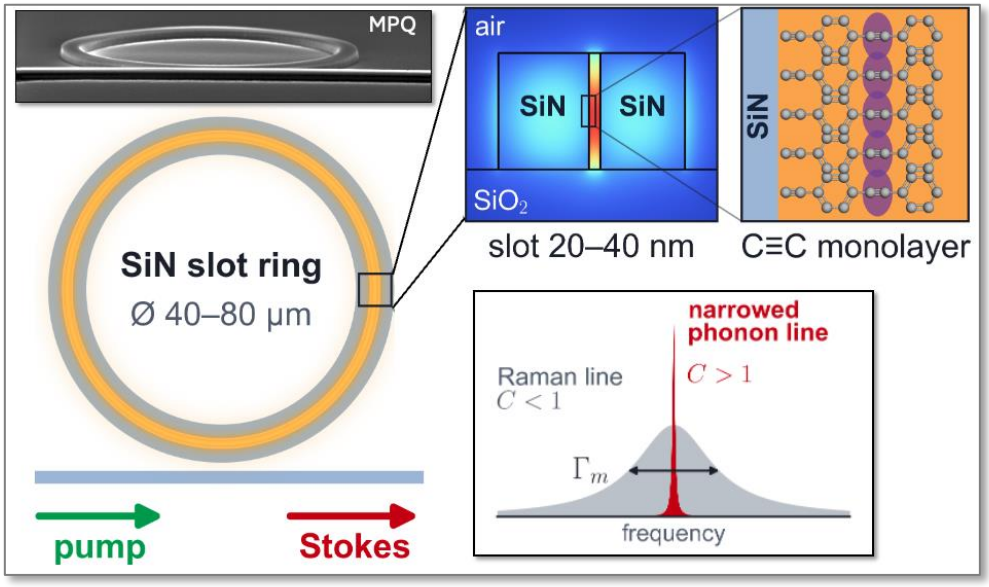


Figure: A silicon nitride micro-ring coupled to the collective vibration of hundreds of millions of molecules grafted in its slot. The optomechanical coupling amplifies this vibration until phonon lasing sets in: above threshold (cooperativity C > 1), the broad Raman line narrows into a phonon-laser line.

The idea. Graft hundreds of millions of molecules into the ~30 nm slot of a silicon nitride micro-ring. There, light sees a single collective vibration, coupled √N times more strongly than one molecule. This vibration behaves as a quantum oscillator in which light writes, reads and amplifies phonons.

The objectives are to demonstrate the first molecular phonon laser, on a chip and at room temperature, and to measure non-classical correlations between the Stokes and anti-Stokes photons scattered by the collective vibration.

During the internship, you will help build the experimental bench and measure how the Raman line narrows as the pump power approaches the lasing threshold. The internship can be followed by a PhD on the generation and measurement of non-classical states of light and of the molecular vibration.

Profile: interest in experimental quantum optics and nanofabrication.

References:

M. Aspelmeyer, T. J. Kippenberg, F. Marquardt, **Rev. Mod. Phys.** 86, 1391 (2014); I. Shlesinger, I. M. Palstra, A. F. Koenderink, **PRL** 130, 016901 (2023); I. Shlesinger et al., **Sci. Adv.** 9, eadj4637 (2023); Roelli, et al. **ACS Photonics** 11, 4486 (2024)