## Photonic Forces group (AMOLF)

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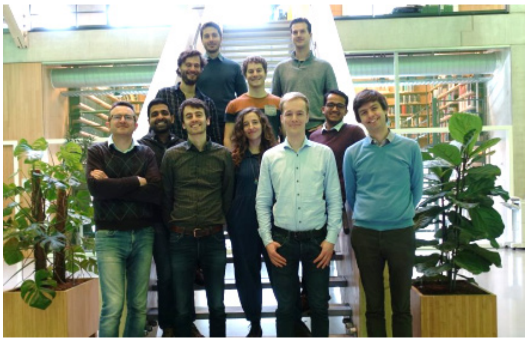
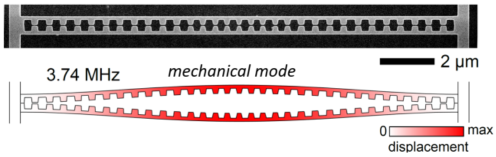


**Research theme** The *Photonic Forces* group studies light-matter interactions at the nanoscale, and in particular the coupling between light and mechanical vibrations, as it can occur through radiation pressure. We use these nano-optomechanical systems to develop new ways to control light and sound on a chip, and study the behavior of nanomechanical resonators down to the quantum regime.

**Project 1. Quantum measurement of ultracoherent nanostrings**

*Supervisors*: Pascal Neveu and Ewold Verhagen

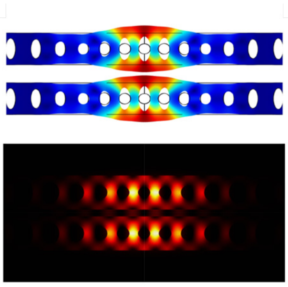



What is the smallest motion one could measure? Normally, Heisenberg's uncertainty relationship provides the answer: the size of the quantum fluctuations of a mechanical resonator sets the lower bound. But with very short, pulsed, optomechanical measurement, one could potentially evade Heisenberg's limit. And if you do, the measurement is so strong that it even alters the quantum state of the object. To reach this, you will seek to develop new nanomechanical resonators made from silicon nitride, in which mechanical decoherence could be extremely small. Using design and fabrication tools of the AMOLF cleanroom, you will integrate these resonators with nanophotonic cavities and characterize their performance in high-precision optical measurement.

**Project 2. Cooling a mechanical resonator close to the quantum ground state using light**

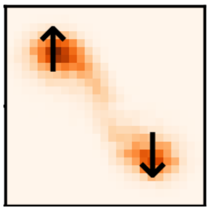
*Supervisors: Roel Burgwal and Ewold Verhagen*

We know from quantum mechanics that any vibration has a minimal energy state. One can use light to cool mechanical vibrations down to this ground state, opening many exciting applications in quantum sensing and computing. This is, however, only possible for 'fast' (GHz-frequency) mechanical vibrations. In this project, you will try to extend the possibility of ground-state cooling to more massive mechanical resonators with lower frequency, by fabricating an optomechanical device with two mechanical modes: one fast and one slow. Through the help of the fast mode, we expect cooling of the slow mode to become possible. This project will involve fabrication of devices in the AMOLF cleanroom, as well as optical testing of the samples in the *Photonic Forces* lab.



**Project 3. Mechanical resonators as 'spins' in light-controlled simulators**

*Supervisors*: Jesse Slim and Ewold Verhagen



There are many useful optimization problems for which an efficient computational algorithm is not known, or may, in fact, not even exist. Recently, for some of these problems, researchers have proposed an unconventional computational method instead: map the problem onto a physical system - the Ising spin model - and solve that system using a programmable *physical simulator*. To build such a simulator, like in the first computers, mechanical elements are once again a candidate building block to carry out the required information processing. We have discovered that nanomechanical resonators controlled through radiation pressure can exhibit parametric gain and nonlinearity that is required to encode spins in an effective Ising simulator. You will fabricate these devices and demonstrate in proof-of-principle experiments that they can be used as such.