Photonic Forces group (AMOLF)

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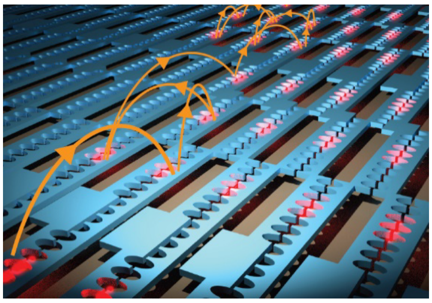
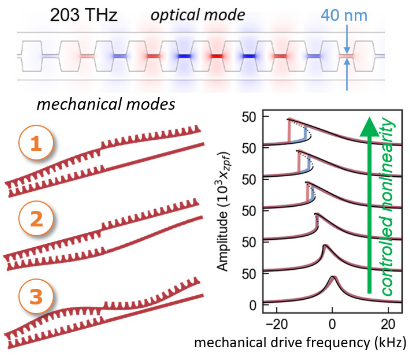
Research theme The *Photonic Forces* group studies light-matter interactions at the nanoscale, and in particular the coupling between light and mechanical vibrations, as it can occur through radiation pressure. We use these nano-optomechanical systems to develop new ways to control light and sound on a chip, and study the behavior of nanomechanical resonators down to the quantum regime.
All projects below will be supervised by Ewold Verhagen, together with a PhD student or postdoc.

Project 1. Laser-controlled optomechanical metamaterials
We have shown that a collection of mechanical resonators can be actively coupled to one another with the help of laser light, in suitable on-chip nano-optomechanical systems. Laser driving then controls the transport of vibrations – sound waves – in such an 'optomechanical metamaterial', and makes them behave different than in any known natural material: For example, it can forbid transmission in one direction, or create exotic topological states of sound that are normally associated with electrons rather than phonons. In this project, you will develop a new type of optomechanical metamaterials which couple many more degrees of freedom, to observe such intriguing physics. The project combines simulations, cleanroom nanofabrication, and optical characterization.



Project 2. Computation with nano-optomechanical resonators
There is high interest in alternative paradigms for computing, for specific applications related to analog simulation and artificial intelligence, and to study fundamental thermodynamic principles that govern the performance of information processing systems. Under the right conditions, computational tasks can be encoded in nonlinear resonators. Very strong nonlinearities can be induced in nanomechanical resonators through their radiation pressure interaction with laser light. In this project, we will explore which nanomechanical gates can be realized by choosing smart temporal modulations of laser light that controls the system. Through sensitive optomechanical readout, we will test computation performance at the thermal noise limit. You will fabricate these optomechanical devices and demonstrate in proof-of-principle experiments that they can be used as small computing elements.



Project 3. Slowing down and localizing light in photonic crystals with synthetic strain
Photonic crystals are dielectric slabs whose two-dimensional periodic pattern can strongly influence the propagation of light in the slab. We recently demonstrated that gradual deformations of a crystal can bring about striking behavior: light is brought to a halt and strongly enhanced as a result. The mechanism is related to the physics of electrons in strained graphene, which features flat bands known as Landau levels. In this project, you will investigate these states and explore the possibility of using different synthetic strain patterns to localize and enhance optical fields over a large area – important to applications such as lasing and sensing. We aim to test the prediction that these trapped photonic states have very long lifetimes, and to study the effects of disorder. The project involves design, nanofabrication in the cleanroom, and optical experiments.