Interacting Photons group (AMOLF)
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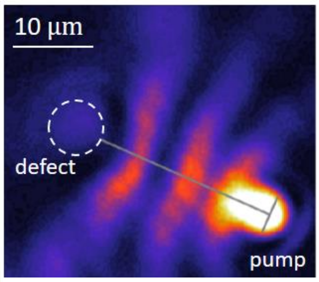
Research theme The *Interacting Photons* group studies strong light-matter interactions in optical cavities. We search for new physics emerging from photons interacting with each other, a noisy environment, excitons, and/or electrons. As a testbed for new ideas, we use tunable microcavities which offer great flexibility in probing the dynamics of complex optical systems. We are also interested in applying fundamental physics concepts to improve sensing, energy transport, and computation.

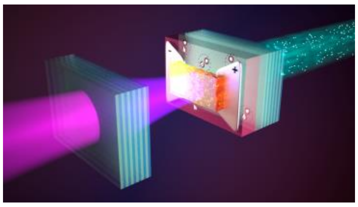
Project 1. Superfluidity of light at room-temperature (experimental)
Supervisors: Giel Keijsers and Said R. K. Rodriguez



Interference fringes due to light scattering at a defect. In the superfluid regime (not shown), scattering and fringes vanish.

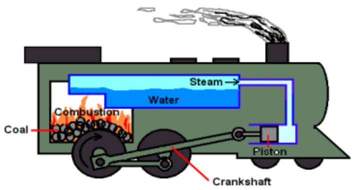
Superfluidity is a fascinating phase of matter characterized by frictionless flow. Recently, we have discovered that light in a nonlinear Fabry-Perot cavity can behave as a superfluid at room temperature [arXiv:2012.13463]. This discovery was made by a MSc student in our group (G. Keijsers, now PhD student), and we are now searching for a MSc student to reveal the properties of this superfluid of light. By joining this project, you would answer questions such as: what happens when two superfluids, which cannot backscatter, meet each other?

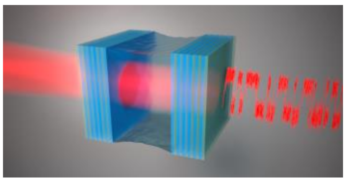
Project 2. Superconductivity induced by light (experimental)
Supervisors: Joris Busink and Said R. K. Rodriguez



Superconductivity is a fascinating state of matter where electron pairs flow without resistance. Superconductivity at ambient temperature and pressure is the greatest unfulfilled dream in physics and materials science. Recently, it was predicted that by embedding a two-dimensional electron system (2DES) and an excitonic system in an optical cavity, the 2DES can undergo a transition for a superconducting state as the light intensity in the cavity increases. In principle, this transition may occur at room temperature. During the past 3.5 years, we have been developing an experimental setup that will enable us to test this idea for the first time. We are finally ready for experiments, and we search for a MSc student to join this effort. In this project you will perform correlated electrical and optical measurements of 2D materials inside an optical cavity at variable temperatures.

Project 3. Stochastic thermodynamics of light (theory, with possibilities for experiments)
Supervisors: Kevin Peters and Said R. K. Rodriguez





Does light in an optical cavity abide by the laws of heat engines?

The laws of thermodynamics and electromagnetism embody the triumph of 19^{th} century physics. While Maxwell's equations are generally viewed as settled, thermodynamic laws remain under scrutiny. This scrutiny began with the recognition that thermodynamics was developed to describe macroscopic systems (e.g. heat engines) operated quasi-statically and unaffected by fluctuations. However, fluctuations are prominent and speed is important in many mesoscopic systems. How, then, can the thermodynamic efficiency of those systems be assessed? The field of stochastic thermodynamics (ST) offers answers to this question, when formulated for material systems. But can the same ST principles be used to assess systems where energy and information are stored in light? In this project, you will answer that question. You will develop a new ST framework for describing optical processes in terms of work, heat, free energy, and entropy. Using that framework, you will make quantitative predictions about stochastic nonlinear optical systems and verify those predictions in simulations and/or experiments.