Interacting Photons group (AMOLF)

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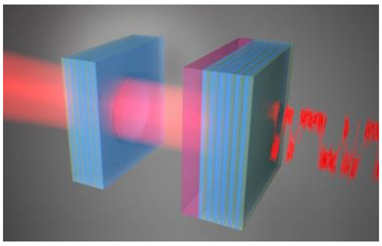
Research theme. The transport of energy and information in light underlies numerous technologies and even our existence. Research in the Interacting Photons group is driven by the conviction that the most effective mechanisms by which light can carry energy and information are still poorly understood or unknown. Consider, for example, that humanity's light-based technologies generally avoid disorder, nonlinearity, and noise. In contrast, certain light-harvesting complexes in plants and bacteria can transport energy with nearly perfect efficiency while being disordered, nonlinear, and strongly influenced by noise. Indeed, a combination of losing strategies becomes a winning strategy according to Parrondo's paradox in game theory. Motivated by the above recognition, the Interacting Photons group investigates (experimentally and theoretically) optical systems where nonlinearity, noise, and disorder, can synergistically enhance the transport of energy and information in light.

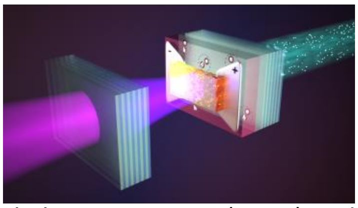
Project 1. The cost of erasing one optical bit (*experiment+theory*)
Supervisors: Kevin Peters and Said R. K. Rodriguez



Light in a cavity can switch between two states, '0' and '1'. Your goal is to make this switch in the most energy-efficient, fast, and precise way allowed by the laws of thermodynamics.

In 1961 Rolf Landauer made a groundbreaking discovery: *Information is Physical*. Landauer showed that erasing one bit of information—an elementary step in computation—requires at least $k_B T$ ln(2) of energy. Recently, optical systems have been touted as promising candidates for energy efficient computing. However, the optical analog of Landauer's limit (bounding the energy efficiency of optical computers) is still unknown. Establishing this limit requires, first of all, to define a temperature for light. Over the past years, our group has made important progress in this direction by developing a new framework called 'Stochastic Thermodynamics of Light'. In this project, you will contribute to construct and experimentally demonstrate the principles of this framework when applied to the simplest information-processing optical system: a cavity storing one bit of information in light. This project has both an experimental and a theoretical part. The balance can be adjusted depending on your interests.

Project 2. Superconductivity induced by light (*experiment*)
Supervisors: Giel Keijsers 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 4 years, we have been developing an experimental setup 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 materials inside an optical cavities at variable temperatures.

Project 3. Breaking of detailed balance in a perovskite semiconductor cavity (*experiment+theory*)
Supervisors: Giel Keijsers and Said R. K. Rodriguez

The principle of detailed balance is one of the most fundamental in physics. It states that the transition rate between 2 states is NOT direction dependent. Recently, our group observed the breakdown of detailed balance in an optical system for the first time. The system is a cavity containing a perovskite semiconductor crystal and driven by a noisy laser. Your goal in this project will be to discover the origin of, and characterize, this effect which opens up new perspectives for controlling energy flow in light.