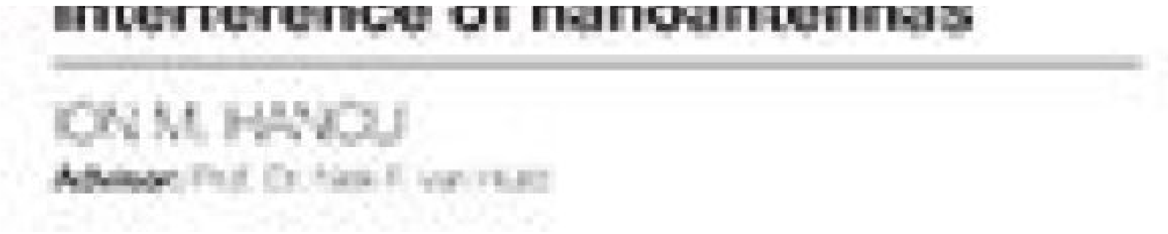

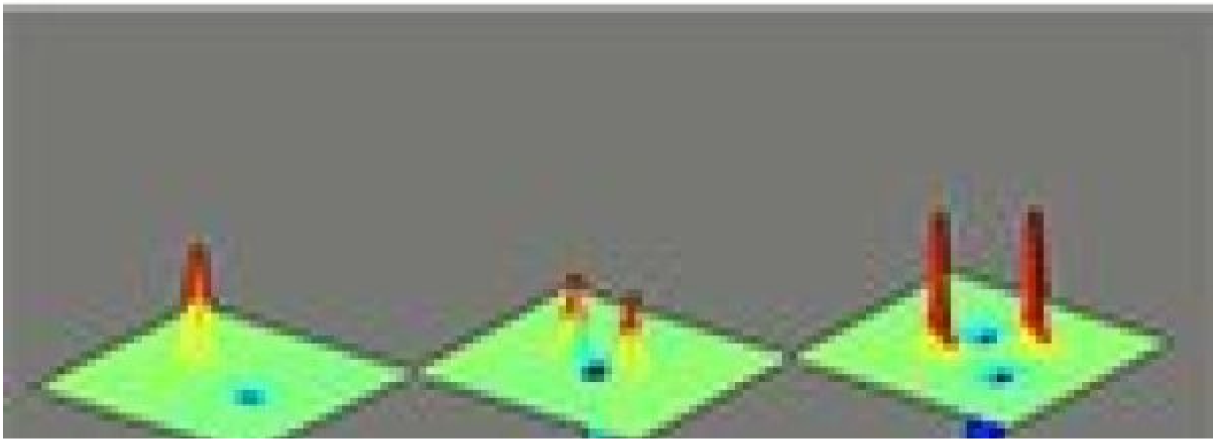

PhD Thesis Defense ION HANCU 'Controlling the multipolar interference of nanoantennas'

ION HANCU

January 18, 2019

PhD Thesis Defense, January 18, 2019, 15:00h. ICFO Auditorium

ION HANCU

Molecular Nanophotonics

ICFO-The Institute of Photonic Sciences

The emission and detection of light is a main pillar of both fundamental research and the advancement of modern technologies. From digital communications and quantum computing to novel cancer treatments and faded jeans, light-matter interactions are at the core of each of these things, and the fundamental building block of nearly every one of these interactions is the electric dipole. The emission and absorption from every molecule, atom, quantum dot and semiconductor is predominantly electric dipole by nature. While it is the most efficient, fastest, brightest, and easiest to understand process, it is not the only process by which light can be emitted and absorbed; magnetic dipoles, electric quadrupoles, and more, all exist in nature.

Optical nanoantennas are the basic element for efficient interfacing between photons and single photon emitters, as they address the inherent size mismatch between the physical size of the emitters and the much larger wavelength of light with which they interact. Optical nanoantennas are also generally electric dipole in nature, as their fundamental resonance is that of an oscillating positive and negative charge. However, unlike nature, these antennas can be engineered to promote higher order modes so that non-electric dipole resonances are not the only contributor.

The topic of this Thesis is the control of light emission through modes beyond the electric dipole, both from single emitters coupled to optical nanoantennas and from the emission of light directly from the antennas themselves. In the Introduction, we provide an overview of basic antenna theory, and in Chapter 1, we describe the experimental and theoretical methods used throughout this Thesis. In Chapter 2, we direct light emission from a quantum dot coupled to a two-dimensional antenna excited at a higher-order mode, and represent its emission pattern with a multipole expansion. To demonstrate the importance of a characteristic of light unavailable to spontaneous emission, its phase, we measure the angular emission patterns of second harmonic generation directly from single nanoantennas in Chapter 3, and once more model its patterns with the multipole model. In Chapter 4, we delve into the second harmonic generation from a crystalline semiconductor, and detect competing second order nonlinear processes that were not present in the previous chapter. Finally, in Chapter 5 we combine the previous three chapters and design an optical nanoantenna, which through two nonlinear processes that coexist when driven in a higher-order mode, radiates its second harmonic unidirectionally, with a switchable emission direction.

The results in this Thesis demonstrate that not only can optical nanoantennas control light emission from single emitters, but that when they are also the emitters themselves we can actively switch the direction in which light is emitted. With this change in paradigm, we now have a new lever with which to tailor the emission of light at the nanoscale. This coherent control of light emission has potential applications in any technology that benefits from higher light-matter interaction efficiencies, and particularly those that require coherence

Friday January 18, 15:00 h. ICFO Auditorium

Thesis Advisor: Prof Dr Niek F van Hulst