Scuola Superiore di Catania

CORSO SPECIALISTICO
a.a. 2017-2018

Order and Disorder in Nanophotonics

General course description: Understanding and engineering electromagnetic waves in complex media is at the heart of current nano-optics and photonics technologies. The manipulation of materials and fields on the nanoscale is of great importance for a number of device applications such as nano-antennas, ultrafast optical switchers, nanoscale energy concentrators, laser nano-cavities, and optical biochemical sensors. This course, taught in three separate modules by leading experts in the field, offers an interdisciplinary and integrated perspective on the physical principles as well as the engineering applications of optical waves in periodic and aperiodic media. Targeting a broad audience of graduate and undergraduate students, this course will cover both fundamental physical mechanisms and state-of-the-art device applications that are uniquely enabled by the control of light-matter interactions in photonic media with engineered structural complexity.
The course is divided in 3 modules:

MODULE I *Ordered structures in photonics: photonic crystals and light confinement*
Photonic crystals, materials in which the dielectric function is periodic in one, two or three directions, are suitable to control light propagation and light-matter interactions. In these lectures the general working principles will be presented in details and some specific examples will be illustrated.

MODULE II *Aperiodic Order in Nanophotonics: Fundamentals and Device Applications*
Electromagnetic complex media generated by simple mathematical rules, known as Deterministic Aperiodic Structures, have recently attracted significant attention in the optics and electronics communities due to their simplicity of design, fabrication, and compatibility with current material deposition and device fabrication technologies. The ability to manipulate light-matter interactions with such structures provides novel opportunities for current nanophotonics and metamaterials technologies. Besides its fundamental interest, optical waves in deterministic aperiodic environments can give access to a richer optical phase space of great relevance to a number of device applications such as multiband nano-antennas, energy concentrators, complex laser nano-cavities, and multiplexed biochemical optical sensors.

MODULE III *Light in random media: Understanding and exploiting disorder*
The standard approach to device design is based on the predictability of perfect, ordered structures. Structures that can be engineered, simulated, optimized to perform a task and then replicated identically. It is commonly accepted that some degree of disorder is inevitable in any real physical system, but randomness is widely considered to be a nuisance to be minimized or ignored whenever possible.
In recent years a profoundly different concept has emerged: that disorder does not necessarily have to be a problem, rather if properly understood and controlled it can be part of the solution. In particular, since elastic scattering retains wave coherence, interference effects between multiply scattered waves can drastically alter the transport properties in a (possibly) useful way.