

Lessons Plan

Lecturer 1: Jacopo Bertolotti

“Optical Wave Scattering”

Lesson plan

1. Scattering theory

- Extinction, scattering and absorption
- Cross sections
- Scattering matrix and the Stokes parameters
- The Optical theorem

2. Mie theory

- Normal modes
- The extinction paradox
- Whispering gallery modes

3. Scattering from small particles

- The Electrostatic Approximation
- Non-spherical particles
- Metal particles

4. Multiple scattering

- Field multiple scattering and the Lambert-Beer law
- Intensity multiple scattering and the diffusion approximation
- Speckle and speckle correlations

Research seminar: *“Imaging and tracking with speckle correlations”*

Lecturer 2: Marian Florescu

“Hyperuniformity and Local Self-Uniformity in Photonic Systems: Fundamentals and Applications”

Lesson plan

1. Waves and structure

- Wave equations and length-scale separation
- Geometry, topology, and connectivity: anisotropy, isotropy, and symmetry constraints
- Structure as a control variable for wave propagation and interference

2. Periodicity and aperiodicity

- Translational order, symmetry groups, Bragg diffraction, and Bloch modes
- Loss of translational symmetry: aperiodic structures and short-, medium-, and long-range correlations

- Quasiperiodic order and forbidden rotational symmetries: quasicrystals as globally ordered non-periodic media
3. Disorder, correlations, and structural descriptors
 - Uncorrelated and correlated disorder
 - Density fluctuations: statistical isotropy, correlation length, pair correlation functions, and structure factor
 - Local and global descriptors of order and complementary order measures
 4. Correlated uniformity in nonperiodic media
 - Correlated disorder as an alternative to translational order
 - Hyperuniformity and the suppression of long-wavelength density fluctuations in quasicrystals and disordered systems
 - Local uniformity of coordination and geometry: local automorphism, network equivalence, and continuous random networks
 - Interplay between global uniformity and local structural constraints
 5. Photonics in nonperiodic structures
 - Wave propagation and scattering beyond Bloch theory
 - Photonic band gaps in quasiperiodic, hyperuniform, and locally uniform media
 - Multiple scattering and interference in correlated disorder
 - Sensitivity of photonic properties to global and local uniformity
 6. Device concepts and applications enabled by nonperiodic photonic media
 - Anomalous transparency and tailored transmission windows
 - Optical cavities and free-form, disorder-tolerant waveguides
 - Thermal emission control and radiative heat management: broadband solar and solar-thermal absorbers
 - Robust photonic components tolerant to fabrication disorder
 - Opportunities for self-assembly and scalable fabrication

Research seminar: “Order, Aperiodicity, and Uniformity in Structured Photonic Media: From Photonic Crystals to Hyperuniform Disordered Photonic Materials”

Lecturer 3: Monika Fleischer

“Optical nanoantennas”

Lesson plan

1. Principles of optical antennas
2. Top-down nanofabrication of optical antennas – lithographic approaches
3. Nano-optical sensors
4. Localized surface plasmon resonance shift sensing

Research seminar: “Steering and analyzing interactions between single nanoantennas and emitters”

Lecturer 4: Francesco Monticone

“Fundamentals of light interaction with complex media and metamaterials”

Lesson plan:

1. Fundamental principles: Causality, passivity, reciprocity, etc.
2. Physical constraints on the optical properties of (meta)materials
3. Fundamentals of effective medium theory
4. Unconventional electromagnetic wave propagation and scattering effects.

Research seminar: *to be announced*