The control of light-matter interaction in deterministic media without translational invariance offers an almost unexplored potential for the creation and manipulation of highly confined optical fields. Unlike periodic photonic structures, Deterministic Aperiodic Structures (DAS) possess unique light localization and transport properties related to rich spectral features described by multi-fractal energy spectra. However, unlike random media, DAS are defined by the iteration of simple mathematical rules, rooted in symbolic dynamics, prime number theory and L-system inflations, which encode a fascinating complexity. In particular, DAS share distinctive physical properties with both periodic media, i.e. the formation of well-defined energy gaps, and disordered random media, i.e. the presence of localized eigenstates with large field enhancement.

Deterministic aperiodic arrays of metal/dielectric nanoparticles can be utilized to develop novel nanophotonics structures for a variety of technological applications, including Surface Enhanced Raman (SERS) sensing, optical detectors, and enhanced light-emitting and nonlinear components for nanophotonics.

In this paper, by combining dark-field scattering characterization, micro-photoluminescence and near-field optical measurements with accurate electrodynamics calculations based on semi-analytical scattering theories, I will discuss electromagnetic coupling\cite{1,2}, resonant scattering\cite{3}, optical sensing\cite{4} and enhanced Raman sensing\cite{5} in two-dimensional dielectric and metal-dielectric (plasmonic) arrays based on deterministic aperiodic sequences. In particular, I will focus on plasmonic scattering and localization in Fibonacci, Thue-Morse and Rudin-Shapiro lattices fabricated by Electron-Beam Lithography (EBL) on transparent quartz substrates.

In addition, I will discuss the design and scaling rules for the control of plasmonic local fields and far-field radiation patterns in more complex deterministic aperiodic arrays which reproduce the behavior of purely random systems to an arbitrary degree of accuracy.

The possibility to engineer complex metal nanoparticle arrays with distinctive plasmonic resonances extending across the entire visible spectrum can have a significant impact for the design and fabrication of novel nano-devices based on broadband plasmonic enhancement.

References:


