

Announcing the Final Examination of Roxana Rezvani Naraghi for the Degree of Doctor of Philosophy in Physics

Date: Thursday, March 30, 2017

Time: 11:00 a.m.

Room: CREOL 103

Dissertation title: Mesoscopic Interactions in Complex Photonic Media

Abstract:

Mesoscale optics provides a framework for understanding a wide range of phenomena occurring in a variety of fields ranging from biological tissues to composite materials and from colloidal physics to fabricated nanostructures. When light interacts with a complex system, the outcome depends significantly on the length and time scales of interaction. Mesoscale optics offers the apparatus necessary for describing specific manifestations of wave phenomena such as interference and phase memory in complex media. In-depth understanding of mesoscale phenomena provides the required quantitative explanations that neither microscopic nor macroscopic models of light-matter interaction can afford. Modeling mesoscopic systems is challenging because the outcome properties can be efficiently modified by controlling the extent and the duration of interactions.

In this dissertation, we will first present a brief survey of fundamental concepts, approaches, and techniques specific to fundamental light-matter interaction at mesoscopic scales. Then, we will discuss different regimes of light propagation through randomly inhomogeneous media. In particular, a novel description will be introduced to analyze specific aspects of light propagation in dense composites. Moreover, we will present evidence that the wave nature of light can be critical for understanding its propagation in unbounded highly scattering materials. We will show that the perceived diffusion of light is subjected to competing mechanisms of interaction that lead to qualitatively different phases for the light evolution through complex media. In particular, we will discuss implications on the ever elusive localization of light in three-dimensional random media.

In addition to fundamental aspects of light-matter interaction at mesoscopic scales, this dissertation will also address the process of designing material structures that provide unique scattering properties. We will demonstrate that multi-material dielectric particles with controlled radial and azimuthal structure can be engineered to modify the extinction cross-section, to control the scattering directivity, and to provide polarization-dependent scattering. We will show that dielectric core-shell structures with similar macroscopic sizes can have both high scattering cross-sections and radically different scattering phase functions. In addition, specific structural design, which breaks the azimuthal symmetry of the spherical particle, can be implemented to control the polarization properties of scattered radiation. Moreover, we will also demonstrate that the power flow around mesoscopic scattering particles can be controlled by modifying their internal heterogeneous structures.

Lastly, we will show how the statistical properties of the radiation emerging from mesoscopic systems can be utilized for surface and subsurface diagnostics. In this dissertation, we will demonstrate that the intensity distributions measured in the near-field of composite materials are direct signatures of the scale-dependent morphology, which is determined by variations of the local dielectric function. We will also prove that measuring the extent of spatial coherence in the proximity of two-dimensional interfaces constitutes a rather general method for characterizing the defect density in crystalline materials. Finally, we will show that adjusting the spatial coherence properties of radiation can provide a simple solution for a significant deficiency of near-field microscopy. We will demonstrate experimentally that spurious interference effects can be efficiently eliminated in passive near-field imaging by implementing a random illumination.

Outline of Studies:

Major: Physics

Educational Career:

M. S. University of Central Florida, USA, 2015

M. S. University of Tehran, Iran, 2012

B. S. University of Tehran, Iran, 2009

Committee in Charge:

Dr. Aristide Dogariu (Chair)

Dr. Talat S. Rahman

Dr. Laurene Tetard

Dr. Ayman F. Abouraddy (External Committee Member)

Approved for distribution by Dr. Aristide Dogariu, Committee Chair, on March 15, 2017.

The public is welcome to attend.