Title: Spin and Orbital Angular Momenta of Electromagnetic Waves

Abstract:

Energy conservation and momentum conservation are fundamental laws governing electromagnetic (EM) systems. Although engineers in EM field know Poynting's theorem and energy conservation law well, field momentum and Maxwell stress tensor in momentum conservation law were always ignored in most EM engineering books. They are not only important to understand optical force and optical tweezers that was awarded the Nobel Prize in Physics 2018, but also highly linked to some modern EM knowledge, such as spin angular momentum (SAM), orbital angular momentum (OAM), quantum electrodynamics, and topological insulators. This short course will offer a systematic review on the SAM and OAM of EM waves in the aspects of physical understanding, engineering designs, and numerical models. In Part I of this short course, I will clarify theoretical foundations for SAM and OAM of EM waves. The analogy between electron and photon will be presented. Then, I will introduce engineering design routes for OAM generation and detection, including geometric phase based metasurfaces and defects incorporated photonic crystals. In Part II of this short course, I will discuss the spin-orbital interaction in scatterers with different materials and geometries at linear, nonlinear and quantum EM regimes, which are governed by total angular momenta conservation. The linear and nonlinear responses from scatterers of N-fold rotational symmetry are to be numerically simulated by solving Maxwell-hydrodynamic equations and nonlinear coupled wave equations. The electronic transition of an artificial atom illuminated by circularly polarized waves or vortex beams will be investigated with a solution to Maxwell-Bloch equations.

Objective:

(1) clarify theoretical foundations for SAM and OAM of EM waves; (2) introduce engineering design routes for OAM generation and detection; (3) understand spin-orbital interaction between EM waves and scatterers with different materials and geometries at linear, nonlinear and quantum regimes.

Length:

The length of the short course will be 2 hours. The length of Part I will be 50 minutes including Questions and Answers. The length of Part II will also be 50 minutes including Questions and Answers. Between the two lectures, audiences will take a 20-minutes break.

Short Bio-sketch:

Wei E. I. Sha (IEEE M'09–SM'17) received the B.S. and Ph.D. degrees in Electronic Engineering at Anhui University, Hefei, China, in 2003 and 2008, respectively. From Jul. 2008 to Jul. 2017, he was a Postdoctoral Research Fellow and then a Research Assistant Professor in the Department of Electrical and Electronic Engineering at the University of Hong Kong, Hong Kong. From Oct. 2017, he joined the College of Information Science & Electronic Engineering at Zhejiang University, Hangzhou, China, where he is currently a tenure-tracked Assistant Professor. From Mar. 2018 to Mar. 2019, he worked at University College London as a Marie Skłodowska-Curie Individual Fellow. His research interests include theoretical and computational research in electromagnetics and optics, focusing on the multiphysics and interdisciplinary research. His research involves fundamental and applied aspects in plasmonics, photovoltaics, metasurfaces, quantum electrodynamics, and computational electromagnetics. Dr. Sha has authored or coauthored 102 refereed journal papers, 100 conference publications, four book chapters, and two books. His Google Scholar citations is 4001 with h-index of 27. He is a senior member of IEEE and a member of OSA. He served as an Editorial Board Member of Progress In Electromagnetics Research Journals and Guest Editors of IEEE Journal on Multiscale and Multiphysics Computational Techniques and The Applied Computational Electromagnetics Society Journal.