Contemporary Advances in the Science and Technology of Light

A Scientific Workshop on the Occasion of

the international Day of Light

April 27-28, 2019

Tarbiat Modares University

Lecturers:

Prof. Dr. Gerd Leuchs
Max Planck Institute for the Science of Light,
Department of Physics, University of Ottawa
Institute of Applied Physics, Russian Academy of Sciences

Prof. Luis L. Sanchez-Soto
Universidad Complutense, Madrid, Spain

Prof. Jawad A. Salehi
Electrical Engineering Department, Sharif University of Technology, Tehran, Iran

Prof. Hamid Latifi
Fiber optics sensor laboratory
Laser and Plasma research institute and Department of physics
Shahid Beheshti University

Talks	Lecturer	Time	
Opening		09:00 – 09:30	27/04/2019
Resolving starlight: a quantum perspective	Luis Sanchez	09:30 – 10:30	
Break		10:30 – 11:00	
Phase space distribution functions in quantum optics	Gerd Leuchs	11:00 – 12:00	
Lunch Break		12:00 – 13:30	
Information at the core of creation	Javad Salehi	13:30 – 14:30	
Fiber optics sensors	Hamid Latifi	14:30 – 15:30	
Break		15:30 – 16:00	
Discussion panel: Research in Optics and Photonics in Iran		16:00 – 17:30	
Compressed sensing in action	Luis Sanchez	09:30 – 10:30	28/04/2019
The relation between the parameters in Maxwell's equations and the properties of the vacuum	Gerd Leuchs	10:30- 11:30	
Closing		11:30 – 11:45	

Abstracts

Resolving starlight: a quantum perspective
Luis L. Sanchez-Soto

The wave-particle duality of light introduces two fundamental problems to imaging, namely, the diffraction limit and the photon shot noise. Quantum information theory can tackle them both in one holistic formalism: model the light as a quantum object, consider any quantum measurement and pick the one that gives the best statistics. While Helstrom pioneered the theory half a century ago and first applied it to incoherent imaging, it was not until recently that the approach offered a genuine surprise on the age-old topic by predicting a new class of superior imaging methods. For the resolution of two sub-Rayleigh sources, the new methods have been shown theoretically and experimentally to outperform direct imaging and approach the true quantum limits. Recent efforts to generalize the theory for an arbitrary number of sources suggest that, despite the existence of harsh quantum limits, the quantum-inspired methods can still offer significant improvements over direct imaging for subdiffraction objects, potentially benefiting many applications in astronomy as well as fluorescence microscopy.

Phase space distribution functions in quantum optics
Gerd Leuchs

Quantum system can be characterized by a quasi-probability distribution in the phase space spanned by the corresponding conjugate variables. When using the Wigner function, the marginal distributions obtained by projecting onto a particular axis in phase space yields the probability distribution for the corresponding variable. The marginal distributions of two conjugate variables corresponding to orthogonal axes in phase space are related to each other by Fourier transformation. Two variables, one rotated by $\theta < \pi/2$ with respect to the other, are related by a fractional Fourier transform. In this sense, a fractional Fourier transformation can describe any rotation in phase space. In the classical domain, the Wigner distribution is also known as the Wigner-Ville function, and it is directly related to the ambiguity function. In this lecture, I will emphasize the relation between the Wigner-function and observable quantities.

Abstracts Cont'd

Information at the core of creation

Jawad A. Salehi

The purpose of this talk is to describe the role of information and its processing apparatus in various physical and biological systems such as the second law of thermodynamics, photosynthesis, black-holes, and universe. I begin with a discussion on the relationship between logical information (Shannon) and physical information (Boltzmann) and argue that information can be lost, but it cannot be destroyed. Taking advantage of general relativity, special relativity and quantum mechanics, I'll discuss that the universe can be realized as a computational machine with 10120 operations on 1090 bits over its 10 billion years of existence. I'll also describe a fascinating process namely quantum walk, as opposed to a random walk, in quantum biological systems, such as photosynthesis, and describe the fundamental algorithm based on the quantum walk that miraculously speeds up the exciton energy transfer, created by absorbing a photon, to reaction-center. I will close my discussion on a philosophical note that the creation of "information" may indeed have superseded the creation of physical, chemical and biological processes and systems.

Fiber optics sensors

Hamid Latifi

Sensors can measure, quantify and translate magnitudes from various physical parameters to an electrical signal. Optical Fiber Sensors (OFSs) have been known as contemporary groups of sensors in which the changes of intensity and/or wavelength shift of transmitted or reflected optical signal in some part of an optical fiber system are analyzed in order to monitor various environmental parameters. Recently, various OFSs have been reported for demands in the measurement of physical, chemical, and biological parameters. there have been widespread advancements in the application, sensitivity enhancement, structure, fabrication, and signal processing techniques in fiber optics sensors.

Abstracts Cont'd

In this talk, we will briefly overview some topics regarding advancements in application, sensitivity enhancement, sensor structure, fabrication and signal processing technique. We will also discuss some of the work done in our fiber optics sensor laboratory. Microspherical fiber optic sensor for measuring micro-Newtonian force and temperature in biological applications will be discussed. Also, fabrication and characterization of a polymeric tapered optical fiber sensor as a flowmeter in a microfluidic channel, micro polymeric Fabry-Perot sensor for simultaneous measurement of pressure and concentration of acetone gas is described. Some of the others works done in the such as magnetic field measurement, polymeric micro-optical sensor for measurement of Acetone gas concentration, optomechanical micro polymeric cantilever based optical fiber sensor, simultaneous measurement of strain and temperature using fiber loop mirror and side hole fiber, detection of acoustic waves by optical fiber Bragg grating sensors and optical fiber loops mirrors as a tool to detect partial discharging in Transformers will be explained.

Compressed sensing in action

Luis L. Sanchez-Soto

Given the rapid progress in quantum technologies, verifying the correct functioning of processes and obtaining accurate tomographic information about quantum states becomes increasingly important. Compressed sensing, machinery derived from the theory of signal processing, has emerged as a feasible tool to perform robust and significantly more resource-economical quantum state tomography for intermediate-sized quantum systems. In this talk, I will provide an overview analysis of compressed sensing techniques in the regime in which tomographically complete data is available with reliable statistics from experimental observations and show recent experimental results obtained with single-photons carrying orbital angular momentum.

The relation between the parameters in Maxwell's equations and the properties of the vacuum.

Gerd Leuchs & Luis Sánchez-Soto

The electric fields around a charge polarize the vacuum. In this model, one treats the vacuum as a dielectric with a dielectric function ε_0. The induced virtual electron-positron dipoles partially screen the point charge. As a result, the charge of the electron seems to increase with increasing exchanged momentum e.g. when studying electron-electron scattering. Equivalently, the fine structure constant $\alpha = e^2/(4\pi\varepsilon_0\hbar c)$ increases with increasing exchanged momentum. This refers to the running of the fine structure constant. Alternatively, one can say electric charge stays constant but that the dielectric function of the vacuum ε_0 must reduce, making the link to the dielectric properties of the vacuum. The lecture will introduce the topic and present a phenomenological model leading to the same qualitative behavior, while also suggestion a link to Maxwell's equations and thus to classical optics.