Laser systems: History and advances in nonlinear spectroscopy and imaging systems

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Abstract

The first laser was demonstrated by Theodore Maiman in 1960 using a ruby crystal. The following year, Franken and his colleagues used this laser to demonstrate second-harmonic generation in a quartz crystal. Since then, laser science and nonlinear optics have advanced in tandem, enabling the development of new spectroscopic technologies that are driving significant progress in scientific research, industrial manufacturing, medicine, and photonics. Advances in laser physics, optical materials, and photonic engineering have enabled the development of laser systems with greater efficiency, higher output power, improved precision, broader wavelength tunability, and increasingly sophisticated control over their temporal and spatial properties. This lecture will review the history of laser and nonlinear optics and explore the fundamental principles and emerging developments shaping modern laser technologies. Emphasis will be placed on the interplay between laser physics, optical materials, and system design. Topics will include advanced solid-state lasers, tunable laser sources, ultrafast laser systems, nonlinear optical processes, frequency conversion, and the generation of radiation across a broad spectral range, from the ultraviolet to the mid-infrared. The roles of optical crystals as laser gain media and as functional components for wavelength conversion, electro-optic modulation, and ultrashort-pulse generation will also be discussed. The lecture will also highlight the integration of advanced laser systems into spectroscopic and microscopic techniques for biomedical diagnostics and optical imaging.

About the presenter

Dr Aladin Mani earned a BSc in Solid-State Physics from Damascus University, Syria; an MSc in Optoelectronics from the University of Liège, Belgium; and a PhD from the University of Namur, Belgium. He is an experienced academic researcher specializing in multidisciplinary research and development projects involving laser physics, laser spectroscopy and microscopy, photonics, optoelectronics, nonlinear optics, and Multiphysics 3D modelling. His research interests include industrial tunable lasers spanning the infrared to ultraviolet, picosecond and femtosecond laser systems, optical imaging systems, and

ultrasonic imaging systems. Dr Mani has authored or co-authored more than 48 publications. Dr Mani is currently a Laser Engineering Scientist at the ELYSE Platform of the Institute of Chemistry and Physics at Université Paris-Saclay, France. He has also served as a principal investigator and senior researcher at several institutions worldwide, including the University of Namur in Belgium and the University of Limerick in Ireland, and as R&D Manager at LaserSpec in Belgium. He is an active member of OPTICA, formerly the Optical Society of America (OSA). Dr Mani has more than 20 years of experience implementing national and international scientific projects supported by programmes including Science Foundation Ireland and the European Framework Programmes FP6, FP7, and Horizon 2020.