Fiber-Optic Quantum Communications and Information Processing

Prof. Prem Kumar
(Northwestern)

Talk abstract: Recognizing the ubiquitous standard optical fiber for long-distance transmission and the widespread availability of efficient active and passive fiber devices, there are significant efforts underway to develop practical resources for quantum communications and information processing in optical fiber networks. Entanglement, which refers to the nonclassical dependency of physically separated quantum systems, is one such resource that is essential for implementing many of the novel functions of quantum information processing. Therefore, the efficient generation and distribution of quantum entanglement in fiber optical systems is of prime importance. Entanglement has been historically produced by use of the spontaneous parametric down-conversion process in second-order nonlinear crystals, wherein one higher-frequency pump photon splits into two lower-frequency daughter photons which can be entangled. Coupling such down-converted photons into optical fibers without degrading entanglement, however, has remained a challenging task. Fortunately, the prospects for ready availability of entanglement in the telecom band have dramatically improved in the last few years by the emergence of a new technique for generating entanglement directly in the fiber itself. This technique utilizes the Kerr nonlinearity of standard optical fiber to produce quantum correlated photons through the spontaneous four-wave mixing process. The correlated photons can be entangled in various ways by incorporating indistinguishable pathways in the four-wave mixing amplitude. In this lecture, I will review the status of this field by describing recent experiments that demonstrate the generation and distribution of quantum entanglement is wave-division multiplexed optical fiber systems. I will also present some recent results on utilizing such entanglement for quantum communications and information processing tasks.

Speaker biography: Prem Kumar is the AT&T Professor of Information Technology in the department of Electrical Engineering and Computer Science and Director of the Center for Photonic Communication and Computing in the McCormick School of Engineering and Applied Science at Northwestern University. He also holds an appointment as Professor of Physics and Astronomy and joined Northwestern in 1986 after spending five years at MIT as a research scientist. He received a Ph.D. in physics from the State University of New York at Buffalo in 1980. He is the author or co-author of over 400 publications, including one edited book, six patents, over 140 papers in peer-reviewed journals, 40 articles in hard-bound volumes, and over 80 invited conference papers. His research focuses on the development of novel free-space and fiber-optic devices for ultrahigh-speed optical and quantum communication networks. He is a fellow of the Optical Society of America (OSA), a fellow of the American Physical Society (APS), a fellow of the Institute of Electrical and Electronic Engineers (IEEE), and a fellow of the Institute of Physics, UK (IoP). In 2006 he received the Martin E. and Gertrude G. Walder Research Excellence Award from Northwestern University and in 2004 he was the recipient of the 5th International Quantum Communication Award established by the Tamagawa University in Tokyo, Japan. On the academic side, his professional services have included Associate Editor, Optics Letters; General (Program) Co-Chair, QELS 2008 (2006); Principal Organizer, 4th International Conference on Quantum Communication, Measurement, and Computing, 1998. On the business side, he is the founder of NuCrypt LLC, a startup company focusing on the commercialization of quantum encryption technology for securing the physical layer of fiber-optic and free-space optical networks.