Modelling and Analysis of Fiber Devices:
Fiber Gratings and Photonic Lanterns

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We discuss our recent work on the modelling and analysis of fiber devices, namely, fiber Bragg gratings (FBGs) and long period gratings (LPGs), and photonic lanterns.

Fiber gratings-FBGs and LPGs are commonly used for applications in communication and sensing. The coupled mode theory and the transfer matrix method are the commonly employed methods for the analysis of light propagation in FBGs and LPGs. However, the coupled mode theory is applicable only when the index contrast is small or the perturbation in the core index is weak, and the transfer matrix approach works well with plane wave approximation. The spit-step non-paraxial (SSNP) method that we have developed earlier is bidirectional and is inherently capable in dealing with the reflections in propagation. Generally, propagation methods are used in Cartesian coordinates as the finite-difference schemes are used for obtaining numerical solutions. However, fiber gratings are best analyzed in radial coordinates due to their azimuthal symmetry. We have developed the SSNP for radially symmetric structure using the collocation method with radial basis functions, namely, the Laguerre-Gauss functions. The advantage is that a 3D structure is modelled in a 2D framework with attendant advantage in computational effort. The method is applicable for radially symmetric structures. The effects of the chirping and apodization in the FBGs and LPGs can be investigated very easily. Modelling of sensors which retail the symmetry can be very easily done using this method. Phase shifted gratings used in laser designs can also be analysed. Some examples will be presented.

The *photonic lantern* is an optical fiber device, which is realized by adiabatic tapering of a bunch of single mode fibers within a low index capillary, in such a way that *N* such fibers are tapered together to a final multimode structure which can support *N* modes. These were initially designed for application in astrophotonics with an aim to achieve single mode like precision and accuracy along with multimode like light gathering ability. The fan-out and fan-in configurations were later found to have immense applications in the emerging frontiers of optical fiber communication like space-division multiplexing and mode-division multiplexing. The taper transition in such devices is required to be adiabatic, achieved at the cost of large device lengths. Simulation studies on such three dimensionally varying long structures using conventional methods are computationally very intensive. Exploit adiabaticity for efficient computing, we have developed an efficient propagation algorithm as well as a method for optimization of device lengths in adiabatically tapered photonic devices. Some examples will be presented.

Biography

Anurag Sharma is a JC Bose Fellow and Emeritus Professor at Optics and Photonics Centre and Physics Department at IIT Delhi and has been teaching since 1980. His research has been concerned with propagation of light in imaging and waveguiding devices. He has published over 110 journal papers and over 200 conference papers. He was a Humboldt fellow during 1982-83 at IPQ (then IHQ), KIT (then Uni-KA). He was an Associate of the International Centre for Theoretical Physics, Trieste during 1988-2006. He received the Shanti Swarup Bhatnagar Prize in 1998 for his research contributions. He is a recipient of the Lifetime Achievement Award of IIT Delhi. He is a fellow of all the three Indian science academies (INSA, IAS and NASI), the Indian National Academy of Engineering, and of Optica (USA). He has been the President of the Optical Society of India and Vice-President of INSA. He is currently a Vice-President of NASI and Chairperson of its Delhi Chapter. Recently, he teamed up with some of his colleagues in setting up of an Optics and Photonics Centre (OPC) at IIT Delhi. The Centre aims at consolidation and growth of activities in both traditional optical engineering as well as in modern technologies including sensing, communication, imaging, beam shaping, and quantum communication.