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Modal and Propagation Studies of Photonic Lanterns

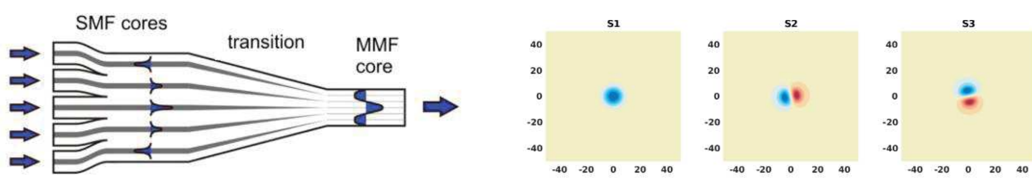
Anurag Sharma, and Sugeet Sunder
Indian Institute of Technology Delhi, Hauz Khas, New Delhi, India
e-mail: asharma@iitd.ac.in;

The “photonic lantern,” is an optical fiber device, that has emerged from the field of astrophotonics, it allows for a single-mode photonic function to take place within a multimode fiber. The fan-out and fan-in(fig1.a) configurations were later found to have immense applications in the emerging frontiers of optical fiber communication like Space-Division multiplexing and Mode-Division multiplexing. We present our study of the modal behavior as well as propagation characteristics of such devices, with an objective to understand the important design parameters and their effects on its functionalities. Here, we present three different studies that we performed on these devices.

Firstly, these devices are generally fabricated by adiabatic taper of a ‘N’ single- mode fibers bunched inside a low-index capillary, such that at the end of the taper, the final structure supports ‘N’ modes of a few-mode fiber. Owing to the constrain of adiabaticity, these devices have large device lengths, which further scale quadratically with ‘N’. We have developed a propagation algorithm which uses the concept of adiabaticity to speed up the calculations of I/O characteristics as opposed to finite difference calculations. For the simplest case of a three-core photonic lantern, we found the difference of the speeds to be over 20 times, where our algorithm was taking 30 minutes as opposed to over 10 hours of computing time taken by the beam propagation method. The algorithm apart from being fast is also very intuitive and can be used for designing photonic lanterns with required degrees of mode-selectivity.

Second, adiabatic taper transitions as discussed are slow, thus affecting device lengths. Shortcuts to adiabaticity is a class of techniques used widely in quantum control theory [1], to speed up the process while maintaining the basic tenets of adiabaticity. We have applied the fast quasiadiabatic dynamics to determine the optimal adiabatic taper profile. These tapers profiles were found to decrease the device length considerably, while maintaining adiabaticity.

Finally, with the increased interest of the photonics community in OAM, we are working on the study of propagation of OAM modes and their selective excitation in such devices.



(a) (b)

Figure 1(a). Schematic of the fan-in part of the Photonic Lantern, **1(b).** Field distribution of the three different supermodes as obtained by our method for the parameters used in [2], the authors have used the conventional beam propagation method.

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