ESPCI PARIS

PhD Position:

Controlling the Propagation of Light in Multimode Fibers

Laboratory:

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Contact:

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Context and motivations:

The control of light propagation in optical multimode fibers is an active and fast growing field of research. Today, most long haul transmission systems and an increasing part of home Internet services rely on optical fibers. However, these systems are about to reach their theoretical limit while the capacity need undergoes a constant increase of 30 to 40 % each year. Optical fibers currently deployed for long haul transmissions are *single mode fibers*: light can only follow one unique path. However, there exists *multimode fibers* in which light can take different trajectories. Taking advantage of the spatial degrees of freedom would allow increasing significantly the number of channels, similarly to MIMO (Multiple-Inputs / Multiple-Outputs) systems deployed for wireless communications [1, 2, 3]. At the same time, researchers investigate the way to control and study light in multimode fibers for their use as a minimally invasive endoscopic imaging device [4, 5, 6].

In both cases, the reconstruction of a signal or an image is difficult due to three major impairments: (1) the intermodal dispersion or the fact that the light taking different trajectories - or modes - propagates at different speeds, (2) the existence of random coupling between the modes due to the defects and the geometry of the fiber and (3) the presence of losses that do not affect the different modes the same way, referred to as mode dependent losses.

The objective of the PhD candidate will be to study and to control the light propagation in multimode fibers to overcome and take advantage of these effects, generally regarded as perturbations, in order to develop new tools for optical telecommunications and imaging devices.

Project description

Taking advantage of the expertise of the Langevin Institute in the control of light propagation in complex media [7, 8, 9], the PhD candidate will use wavefront shaping techniques to study the effect of perturbations in multimode fibers. In particular, he will measure and study the transmission matrix of multimode fibers [10, 11] in presence of mode coupling. This operator will be studied using mathematical approaches, such as random matrix theory, in order to implement models and protocols that could be used to increase the data rates in commercial systems. By studying the whole communications or imaging system, it is possible to adapt the different parts (modulator, multimode fiber, numerical reconstruction) to each other in order to increase the overall efficiency. In particular, the PhD candidate will investigate the possibility to influence or control light propagation inside the multimode fiber by changing the boundary conditions.

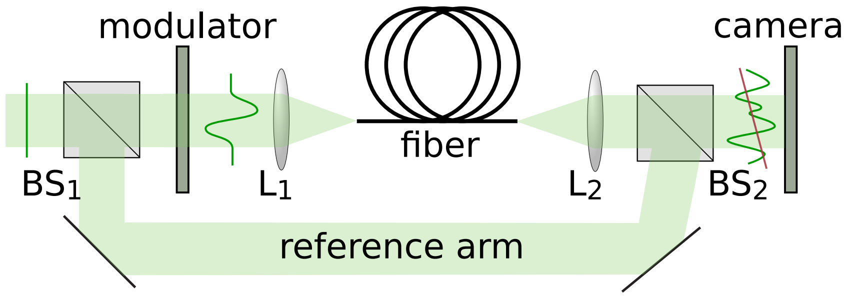

Figure 1: Setup for the measurement of the transmission matrix of a multimode fiber.

Candidate profile

The candidate should have a Master's degree in Optical Engineering, Physics, Computer Sciences, Applied Mathematics, or a related field. As the project involves experimental, theoretical and simulation works, the candidate should demonstrate multidisciplinary skills. An experience in one or more of those fields would be appreciated: computational imaging or digital signal processing, physics of light scattering or waveguides, manipulation of matrices, experimental optics or optical communications.

The candidate should have a professional working proficiency in English with strong communication skills. Programming skills in C++, Pyhton and/or Matlab are required.

References:

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[7] S.M. Popoff, G. Lerosey, R. Carminati, M. Fink, A.C. Boccara, and S. Gigan. Measuring the transmission matrix in optics: an approach to the study and control of light propagation in disordered media. *Phys. Rev. Lett.*, 104.

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[9] D. Andreoli, G. Volpe, S.M. Popoff, O. Katz, S. Gresillon, and S. Gigan. Deterministic control of broadband light through a multiply scattering medium via the multispectral transmission matrix. *Sci. Rep.*, 5, 2015.

[10] J. Carpenter, B.J. Eggleton, and J. Schröder. 110x110 optical mode transfer matrix inversion. *Opt. Express*, 22(1):96–101, 2014.

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