Postdoctoral position

Langevin Institute - ESPCI - CNRS

Wavefront shaping and study of light propagation in disordered multimode fibers

Work environment and location

The position is available in the *Waves in complex media* group at the Langevin Insitute (ESPCI, CNRS UMR 7587) in the fifth district of Paris (1, rue Jussieu, 75005 Paris) under the supervision of Sébastien Popoff in the collaboration of Julien de Rosny.

Duration

The expected duration is one to two years, with an expected starting date between October 2020 and January 2020.

Contacts

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Context and motivations

The past decade has witnessed a renewed interest in multimode fibers for their potential applications in endoscopic imaging and optical telecommunications. For telecommunications, single modes fibers were favored since their popular emergence in the 1970' and are nowadays the backbone of the long-distance internet network. However, after taking advantage of all the available degrees of freedom offered by the single modes fibers, namely the amplitude, phase, frequency and polarization of the light, we are about to reach the theoretical maximal data-rate imposed by non-linearities.

In this context, multimode fibers emerged as a good candidate to increase data-rates, without proportionally increasing the costs, by taking advantage of the new degrees of freedom offered by the spatial diversity, i.e. the fact that multiple trajectories are allowed to propagate. However, such fibers are not perfect, and the existence of dispersion, mode coupling, and mode dependent losses has the dramatic effect of introducing randomness in light propagation which scrambles the information in an unpredictable way. Similarly to wireless telecommunication, one can use MIMO (Multiple-Input Multiple-Output) approaches to unscramble the data, but at the cost of a heavy computational complexity that exponentially increases with the number of channels.

It is then of the utmost importance to understand and predict the effect of perturbations and randomness in multimode fibers in order to adapt the telecommunication protocols to the disorder and relax the computational complexity of numerical post-processing. When light injected in one mode statistically explores all the other modes with the same probability, i.e. in the *strong coupling regime*, some average properties can be predicted. However, from a few centimeters to a few kilometers, typical multimode fiber systems are not in this regime ; disorder strongly influences light propagation but some aspects of the ordered behavior survives. The intermediate regime has been little investigated until recently [1], and the effect of one, or a set of, given perturbations on light propagation is currently unknown. One reason is the extreme difficulty to measure accurately the transmission matrix [2] of multimode fibers [3, 4]. We recently developed some hardware and numerical tools to easily and quickly acquire this matrix, allowing for instance to study and avoid disorder introduced by a single deformation [5].

Scientific mission

The candidate will be using a wavefront shaping apparatus [6, 5] to characterize and control light propagation inside multimode fibers. The goal is to study the effect of the transition from order to disorder in multimode fibers in the context of telecommunication applications. He or she will be in charge of running and adapting the existing experimental setup, as well as acquiring and treating the data. In this context, the candidate will have use Python to control the experimental hardware and to develop post-treatment procedures for the data.

Applicant profile

This position involves experimental work as well as heavy numerical data treatment. Moreover, some theoretical work about light propagation is expected. Previous experience in wavefront shaping and/or complex media (multimode fibers or scattering media) is required. Strong experience in data treatment (in Python preferentially) is also expected.

References

[1] W. Xiong, P. Ambichl, Y. Bromberg, B. Redding, S. Rotter, and H. Cao, Opt. Express (Sep 2016), optics Express 25, 2709 (2017), https://doi.org/10.1364/OE.25.002709.

[2] S. M. Popoff, G. Lerosey, R. Carminati, M. Fink, A. C. Boccara, and S. Gigan, Physical Review Letters **104**(10) (mar 2010), https://doi.org/10.1103/physrevlett.104.100601.

[3] J. Carpenter, B. J. Eggleton, and J. Schröder, Optics Express **22** (2014), https://doi.org/10.1364/OE.22.000096.

[4] M. Plöschner, T. Tyc, and T. Čižmár, Nature Photonics **9**, 529 (2015), http://www.nature.com/articles/nphoton.2015.112.

[5] M. W. Matthès, Y. Bromberg, J. de Rosny, and S. M. Popoff, in preparation (2020).

[6] M. W. Matthès, P. del Hougne, J. de Rosny, G. Lerosey, and S. M. Popoff, Optica **6** (2019), https://doi.org/10.1364/OPTICA.6.000465.