Shaped waves and speckle correlations: A window into opaque media.

Allard P. Mosk

Light in Complex Systems, Debye Institute for Nanomaterials Science, Utrecht University, The Netherlands
E-mail: a.p.mosk@uu.nl

In this colloquium talk I will give an accessible overview of the emerging field of wavefront shaping in strongly scattering media, highlighting the opportunities for new research.

Random scattering of light, which takes place in paper, paint and biological tissue is an obstacle to imaging and focusing of light and thus hampers many applications. At the same time scattering is a phenomenon of basic physical interest as it allows the study of fascinating interference effects such as open transport channels [1,2], which enable lossless transport of waves through strongly scattering materials.
Propagation of laser light in scattering media can be controlled by shaping the incident wavefront using spatial light modulators. Wavefront shaping methods in scattering media have given rise to a new wave of fundamental studies of light propagation as well as new modalities of imaging and focusing with scattered light. Recently we demonstrated that speckle correlations enable non-invasive fluorescence imaging through strongly scattering layers [3]. Scattering “lenses” made of high-index materials allow wide-field speckle-illumination microscopy with a resolution approaching 100 nm [4].
In waveguides scattering can be exceptionally strong. We have very recently demonstrated dynamic control of resonant scattering using light, which allows interactive control of scattering [5], with the possibility to create a new class of adaptive nanophotonic circuits.
.

References

[1] A. P. Mosk, A. Lagendijk, G. Lerosey, and M. Fink, *Controlling waves in space and time for imaging and focusing in complex media*, Nat. Photon., **6,** 283 (2012).

[2] I.M. Vellekoop and A.P. Mosk, *Universal optimal transmission of light through disordered materials*, Phys. Rev. Lett. **101**, 120601 (2008).

[3] J. Bertolotti, E. G. van Putten, C. Blum, A. Lagendijk, W. L. Vos, and A. P. Mosk, *Non-invasive imaging through opaque scattering layers*, Nature, **491**, 232 (2012).

[4] H. Yılmaz, E. G. van Putten, J. Bertolotti, A. Lagendijk, W. L. Vos, and A. P. Mosk, *Exploiting speckle correlations to improve the resolution of wide-field fluorescence microscopy*, Optica **2**, 424 (2015)

[5] S. Sokolov, J. Lian, E. Yüce, S. Combrié, G. Lehoucq, A. De Rossi, and A. P. Mosk, *Local thermal resonance control of GaInP photonic crystal membrane cavities using ambient gas cooling*, Appl. Phys. Lett. **106**, 171113 (2015)