The speckle wavemeter

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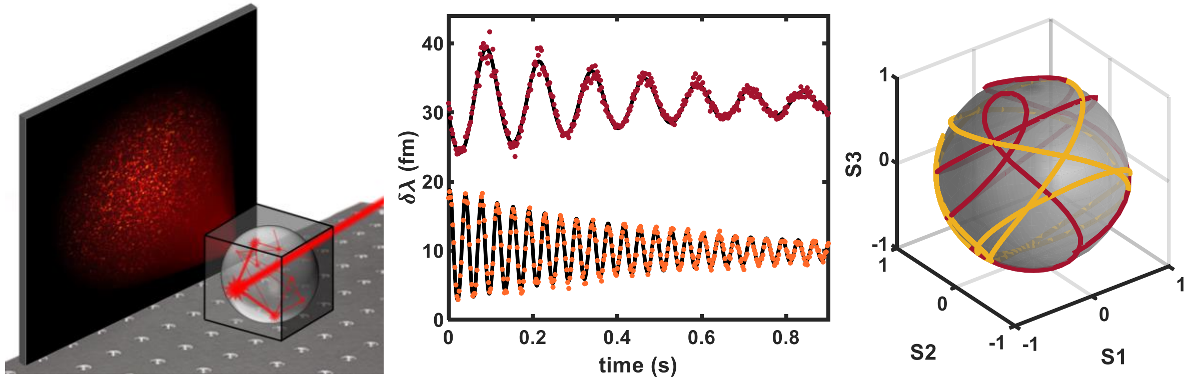
Funder(s): Leverhulme Trust, EPSRC

Abstract

Precision measurement of lasers is required in fields from quantum technology to telecommunications. We develop a counter-intuitive method for accurate measurement of lasers: by using the speckle patterns produced when the light hits a rough surface. From these patterns, we extract the wavelength and polarisation of the laser light using multivariate analysis techniques, realising an attometre-precision wavemeter.

Experimental setup and key results: simultaneous measurements (left) of wavelengths and (right) of polarisations of two lasers



Project Description

Speckle, the granular interference pattern produced when coherent light is scattered by a rough surface, is commonly thought to be detrimental to optical systems. But speckle is surprisingly sensitive to properties of the light and the scatterer, and the processes which form the speckle are entirely linear. This means that if the scatterer is constant in time, the speckle can be used as a fingerprint for properties of the laser. We generate speckle by passing laser light through an integrating sphere or a short (15cm) length of multimode fibre, and analyse changes in the speckle using multivariate analysis techniques including Principal Component Analysis and Convolutional Neural Networks.

Key Results

We have developed methods which allow:

1. attometre-resolved wavelength measurement - Opt. Lett. **44**, 1367 (2019)
2. kHz acquisition-rate wavelength measurement - Opt. Commun. **459**, 124906 (2020)
3. dynamic range of measurement of 10^{11} across the visible and near-infrared - arXiv: 1910.10702
4. femtometre-resolved simultaneous measurement of wavelengths of multiple lasers - Opt. Lett. **45**, 1926 (2020)
5. simultaneous measurements of the polarizations of multiple laser beams - OSA Continuum **3**, 1302 (2020)