IMAGING

Speckle-Free Laser Imaging with Random Laser Illumination

S patial coherence in imaging has one notorious consequence: speckle. It corrupts images and limits laser use in applications ranging from modern microscopy to digital light projectors to photolithography. Most approaches for eliminating speckle involve time-averaging independent speckle patterns, which limits the imaging speed. We have taken a different approach—instead of averaging out the speckle that is already present, we prevent speckle formation by using an unconventional random laser.

A random laser confines light through multiple scattering in a disordered medium.¹ Consequently, it can support a large number of spatially irregular modes that lase simultaneously and independently. The combined emission has low spatial coherence compared to conventional lasers.^{2,3} In fact, by adjusting the gain volume and scattering element concentration, one can tune the spatial coherence of random laser emission over a wide range.³ This provides a unique opportunity to design a bright illumination source whose spatial coherence is tailored for a specific imaging/projection application. We recently presented a series of imaging tests conducted with a random laser designed to produce low spatial coherence and compared the performance to illumination with several conventional sources.⁴

For each configuration we tested, the random laser illumination produced far superior images by suppressing speckle formation. Here, we show an example of imaging a U.S. Air Force (USAF) test chart through a scattering film. While a traditional HeNe laser produces high-contrast speckle that completely precludes our ability to discern the underlying object, the random laser with low spatial coherence prevents speckle formation and the chart remains visible. Although a conventional



(a) Light sources are compared by photon degeneracy and spatial coherence. (b) In the imaging test, an air force (AF) test chart was illuminated by a random or traditional laser and imaged onto a camera (CCD) through a scattering film (S). (c) The low spatial coherence of the random laser prevents the speckle that corrupts the image beyond recognition when using the traditional laser.

Adapted from B. Redding et al. Nat. Photon. 6, 355 (2012).

broad-band laser source can reduce the speckle contrast via spectral averaging, we demonstrated that a random laser with low spatial coherence is much more efficient in eliminating speckle.

The random laser produced images of similar quality to a light emitting diode (LED), which is known to have low spatial coherence. Because the random laser relies on stimulated emission, it can exhibit much higher photon degeneracy (or spectral radiance) than the LED, enabling imaging through highly dissipative media or monitoring dynamic phenomena with short integration times. Moreover, random lasers have already been realized with a host of materials, including semiconductor and fiber, operating at wavelengths across the UV, visible and IR. The ability to combine low spatial coherence with high spectral radiance-two mutually exclusive properties in conventional light sources-could enable a host of parallel imaging applications from full-field microscopy to digital light projection. OPN

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