Spotlight on Optics

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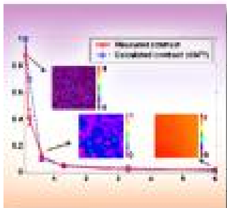

Efficient method for controlling the spatial coherence of a laser

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Spotlight summary: Much of the utility of lasers springs from the high degree of spatial coherence that can be realized across the laser aperture. The correlation of the light field across the beam can be exploited to form a minimally-sized focus or to keep the beam collimated for the maximal distance. In addition to high spatial coherence, lasers offer other attractive properties not easily realized in traditional sources of illumination - in particular, lasers can be very bright and may produce light in a very limited range of wavelengths (i.e., they may also exhibit long temporal coherence). In some applications these optical properties combine synergistically: for example, laser welding employs high brightness and tight focusing to produce very high power densities. In other applications, however, high spatial coherence can become a liability. Foremost amongst these applications is laser-illuminated imaging. Unwanted spatial structure - speckle - is often observed when, for example, object roughness introduces fine-scale spatially-dependent interference effects.

Speckle can be eliminated by illuminating with a laser exhibiting limited spatial coherence, while other desirable properties such as high brightness and narrow bandwidth may be retained. However, the optimal degree of spatial coherence will often be application-dependent and/or empirically determined, and some applications may even require multiple extents of spatial coherence. The most convenient solution is to have a laser system with a tunable degree of spatial coherence so, for example, the coherence can be selected to eliminate speckle but retain high collimation. Coherence can be set externally using a spinning diffuser (to reduce coherence) or a spatial filter (to increase coherence). However, these external methods have drawbacks such as loss of brightness, increased mechanical complexity or extended data-capture times. In this paper the authors use a method internal to the laser to produce a device with widely tunable spatial coherence but consistent brightness. The standard benefits of lasers are maintained but the spatial coherence can be easily set and adjusted.

The key to the authors' method is coupling a degenerate laser cavity (which supports a wide range of modes over a wide range of spatial mode sizes) with an internal spatial filter. This pinhole filter prohibits a fraction of the modes, with the remainder being boosted in the gain medium. In this manner the power is maintained while the number of cavity modes can be controlled. Spatial coherence depends on the number of modes present and is therefore tunable in the device. By changing the size of the spatial-filter pinhole, the authors demonstrate operation from a single mode (maximal spatial coherence) up to approximately 320,000 modes. Over this range, the output power of the laser changes by only about 50%. This paper gives both analytical and experimental demonstrations of the method, with a clear example of how speckle can be reduced. The work is also presented in a manner that is clear and accessible to the reader.

--Brynmor Davis

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