Making the most of interference: speckle metrology and its application to cold atoms

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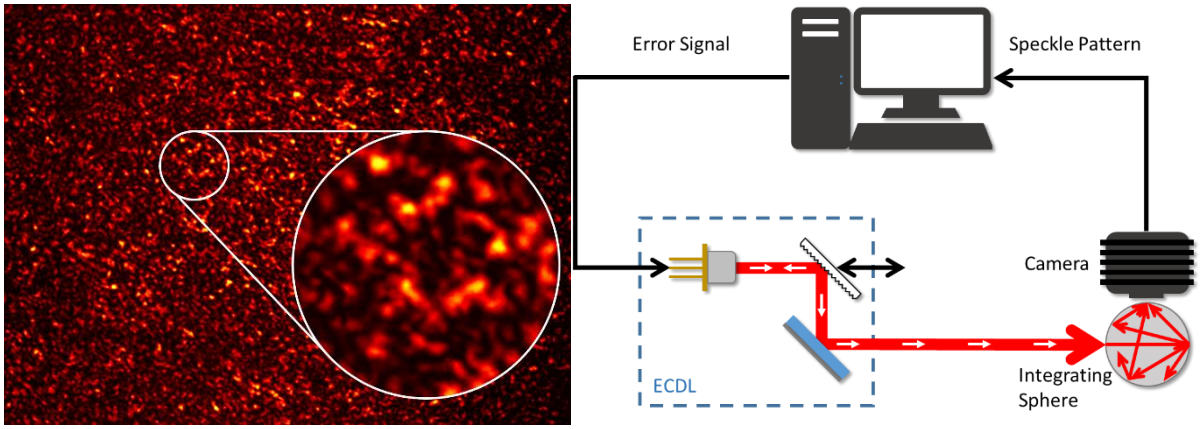
Speckle patterns result from the interference of multiple reflections in disordered media. This is regarded as a randomization process which destroys information contained within the initial light beam and is deleterious to many optical systems. Indeed, many engineers study speckle to remove its effect. Intriguingly however, the processes that produce the speckle are entirely linear, and there is growing recognition that this complex pattern is rich in useful information on both the incident laser source and the environment, with startling potential uses. We will demonstrate our recent results [1], which show that the speckle pattern produced by light propagation in an integrating sphere can be used as a sensitive wavemeter, with a resolution below 1fm. Moreover, this can be used to stabilize the wavelength of a laser on a timescale and to a stability applicable for laser cooling of cold atoms.



(left) An example of a speckle pattern produced in the integrating sphere
(right) Experimental configuration for laser-locking using speckle.

Reference:

[1] N. K. Metzger, et al., “Harnessing speckle for a sub-femtometre resolved broadband wavemeter and laser stabilization”, Nature Communications **8**, 15610 (2017)