Seeing the light with nist's new noiseless optical amplifier

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This short movie shows the image of the 'N' in NIST being randomly amplified and de-amplified by the four-wave mixing technique. The intensity of the image changes randomly because the lasers were deliberately not stabilized with respect to each other when making the video to better illustrate how well the technique worked. Credit: Corzo/NIST

(Phys.org) -- Most devices that amplify light suffer from the same problem: making the image brighter also adds muddying distortion. Scientists working at the National Institute of Standards and Technology have demonstrated that they can amplify weak light signals without adding noise while also carrying more information—more pixels—than other low-noise amplifiers. The new development could improve optical communications, quantum computing and information processing, and enhance biological and astronomical imaging.

Researchers have developed other light amplifiers using "nonlinear" crystals and optical fibers that don't add noise, but they're limited when it comes to amplifying images. Crystals need high laser intensities, which can distort the image. Amplifying light with fibers works well, but the fibers have to be long and the beam is confined to a small area, which constrains the complexity of the image to single pixels.

NIST's four-wave mixing technique amplifies images by intersecting the light from three differently colored lasers—two "pumps" and a probe laser carrying the image—at precise angles inside a gas of hot rubidium atoms. After passing through a stencil in the shape of the image they want to amplify, the probe laser, whose color, or frequency, is halfway between those of the pump lasers, bisects the angle made by the pump lasers. The combination of the lasers' color, their angle of intersection, and their interaction with the rubidium gas creates the conditions for noiseless amplification of complex images with potentially thousands of pixels.

There is a limitation to this kind of an amplifier—it's "phase sensitive." This means that for the amplification to be noiseless, the pump and signal beams going into the amplifier have to remain stable with respect to each other to within a small fraction of a wavelength so that the beams interfere and add up properly. Such a condition on the beams makes it harder to keep them aligned and stable than for the more common "phase insensitive" amplifiers.

According to NIST physicist Paul Lett, this technique can amplify images by a factor of up to 4.6 times the original signal strength.

"The light we use is infrared, which is good for biological and astronomical imaging," says Lett. "Now we just need to show that our technique amplifies the image faithfully, pixel by pixel, so that we can be assured that it is fully practicable."

More information: N.V. Corzo, A.M. Marino, K.M. Jones and P.D. Lett. Noiseless optical amplifier operating on hundreds of spatial modes. *Physical Review Letters*. Published online July 26, 2012.

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