Frequency Comb Pushes Limit of Fiber-Optic Strain Sensing

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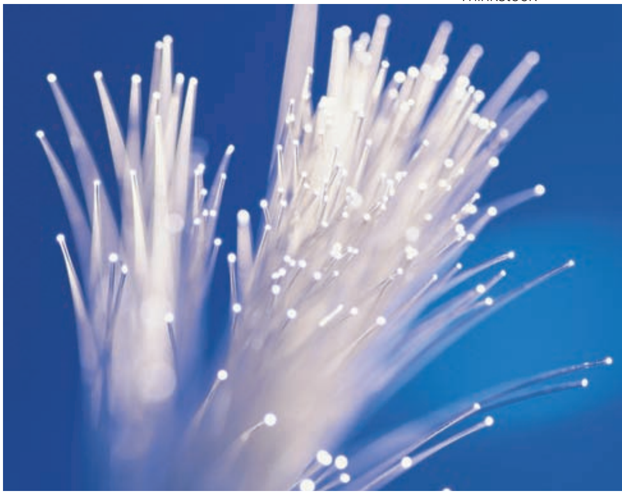


By integrating an optical frequency comb into a fiber-optic strain-sensing system, a team of Italian researchers has made a sensor that is three orders of magnitude more sensitive than existing instruments (Science Express, doi: 10.1126/science.1195818).

Optical sensors using standard telecommunication fibers and fiber Bragg gratings already measure mechanical strain—relative displacements and deformations—with sensitivities between 10^{-6} and 10^{-9} ϵ $Hz^{-1/2}$, where ϵ is the fractional length change of the object being measured. To get strain sensors with pico-ϵ sensitivity or better, engineers have had to build extremely complex gear stretching out over several kilometers (for gravitational-wave experiments) or limit their sensing to high-frequency strain signals.

Gianluca Gagliardi and colleagues at the National Institute of Optics (Naples, Italy) designed a sensor that can track slow deformations. They built a fiber-Bragg-grating resonator sensing system with a 1,560-nm diode laser stabilized against an optical frequency comb—a familiar high-accuracy tool for today's physicists.

The actual sensor consists of two identical single-mode fiber-Bragg-grating reflectors connected to a 130-mm-long silica fiber in an isolated cavity. A piezoelectric actuator applied a periodic displacement of 6.1×10^{-11} ϵ—in other words, a tiny stretching increase over the length of the fiber inside the cavity. Results showed the lower limit of the system's sensitivity was roughly 20×10^{-12} ϵ $Hz^{-1/2}$.

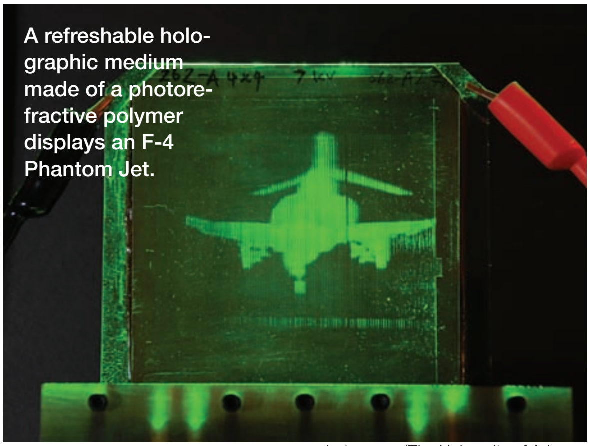
"The laser serves as a secondary length standard that is directly compared to the fiber cavity optical path-length during strain measurements," the researchers wrote. The sensitivity improves markedly when the laser is phase-locked to the frequency comb.

According to the researchers, the sensor system's resolution is now limited to thermal noise in the fiber. They hope that their experiments yield new possibilities for using compact, all-optical-fiber sensors in gyroscopes, gravimeters and the next generation of gravitational-wave detectors.

—Patricia Daukantas

New Technology Produces Real-Time 3-D Holograms

Researchers at the University of Arizona have combined a photorefractive polymer that can be refreshed every two seconds with a system of cameras, computers and an Ethernet link to provide a holographic version of Skype—transmitting and displaying 3-D images over a network in near real time. Lead author Pierre-Alexandre Blanche and others in Nasser Peyghambarian's team developed the system using a polymer from Nitto Denko Technical Corporation (Nature, doi: 10.1038/nature09521).



A refreshable holographic medium made of a photorefractive polymer displays an F-4 Phantom Jet.

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The technology could be used for 3-D video conferencing as well as medical applications prototyping, advertising, updatable 3-D maps and entertainment.

"Holographic stereography has been capable of providing excellent resolution and depth reproduction on large-scale 3-D static images," the authors write, "but has been missing dynamic updating capability until now." The photorefractive material that makes this possible is based on a copolymer that is sandwiched between two indium-tin-oxide-coated glass plates, 100 μm apart. Transparent ITO layers act as electrodes and apply an external electric field required to make the photorefractive material work. Samples of the materials have been used for months without any sign of degradation from crystallization and dielectric breakdown. Sizes of the samples vary from 4 to 17 in.

A frequency-doubled Nd:YAG laser emitting at 532 nm writes each 1-mm-cubic pixel in a 6-ns 200-mJ pulse at a repetition rate of 50 Hz. By using a holographic optical element to split the beam, one can write multiple pixels in parallel. (See movie at: www.uanews.org/node/35109.) In the *Nature* paper, the researchers described