Drive test: NIST Super-stable laser shines in minivan experiment

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NIST researcher David Leibrandt tests the stability of an advanced laser in a minivan. The laser and related instruments are inside the box, which is 2 by 2 by 2.5 feet in size. The stainless steel cylinder at the lower left contains the optical cavity used to stabilize the laser, which is hidden behind the cylinder. Credit: NIST

(PhysOrg.com) -- In a step toward taking the most advanced atomic clocks on the road, physicists at the National Institute of Standards and Technology (NIST) have designed and demonstrated a super-stable laser operating in a cramped, vibrating location—a minivan.

The experiment shows how advanced lasers can be made both stable and transportable enough for field use in geodesy, hydrology, improved radar and space-based tests of fundamental physics.

The drive tests, limited to a short excursion of five meters across the grass at the NIST Boulder, Colo., campus, are described in Optics Express. Scientists evaluated the infrared fiber laser's performance with the vehicle stationary, with the motor alternately off and idling, and moving over uneven ground at speeds of less than 1 meter per second (i.e., 3.6 km/hr). The laser frequency remained stable enough with the car parked—the most likely situation in the field—to be used in some applications now, says David Leibrandt, a NIST post-doctoral researcher.

"Our group has been building and using ultra-stable lasers for more than 10 years, but they're large and delicate," Leibrandt explains. "The ones we use for our optical atomic clocks occupy a small room and have to be very carefully isolated from seismic and acoustic vibrations. This paper presents a new design that is less sensitive to vibrations and could be made much smaller."

NIST scientists stabilized the test laser's frequency using a common technique—locking it to the extremely consistent length of an optical glass cavity. This sphere, about the size of a small orange, hangs in a customized mount with just the right stiffness. The scientists also designed a system to correct the laser frequency when the vehicle moves. Six accelerometers surrounding the cavity measure its linear and rotational acceleration. The accelerometers' signals are routed to a programmable computer chip that predicts and corrects the laser frequency in less than 100 microseconds.

The new laser will make it easier to use advanced atomic clocks for geodesy (measurements of the Earth), an application envisioned by the same NIST research group. The laser also might be used on moving platforms, perhaps in space-based physics experiments or on Earth generating low-noise signals for radar. Study results indicate the laser is roughly 10 times more resistant to undesirable effects from vibration or acceleration than the best radio frequency crystal oscillators. Improved mechanical design and higher-bandwidth accelerometers could make the laser even more stable in the future, the researchers say.

More information: D.R. Leibrandt, et al. Field-test of a robust, portable, frequency-stable laser. *Optics Express*. May 23, 2011 / Vol. 19, No. 11. Published online May 10, 2011.

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