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Ultrafast pulsed lasers… more than just a lightshow

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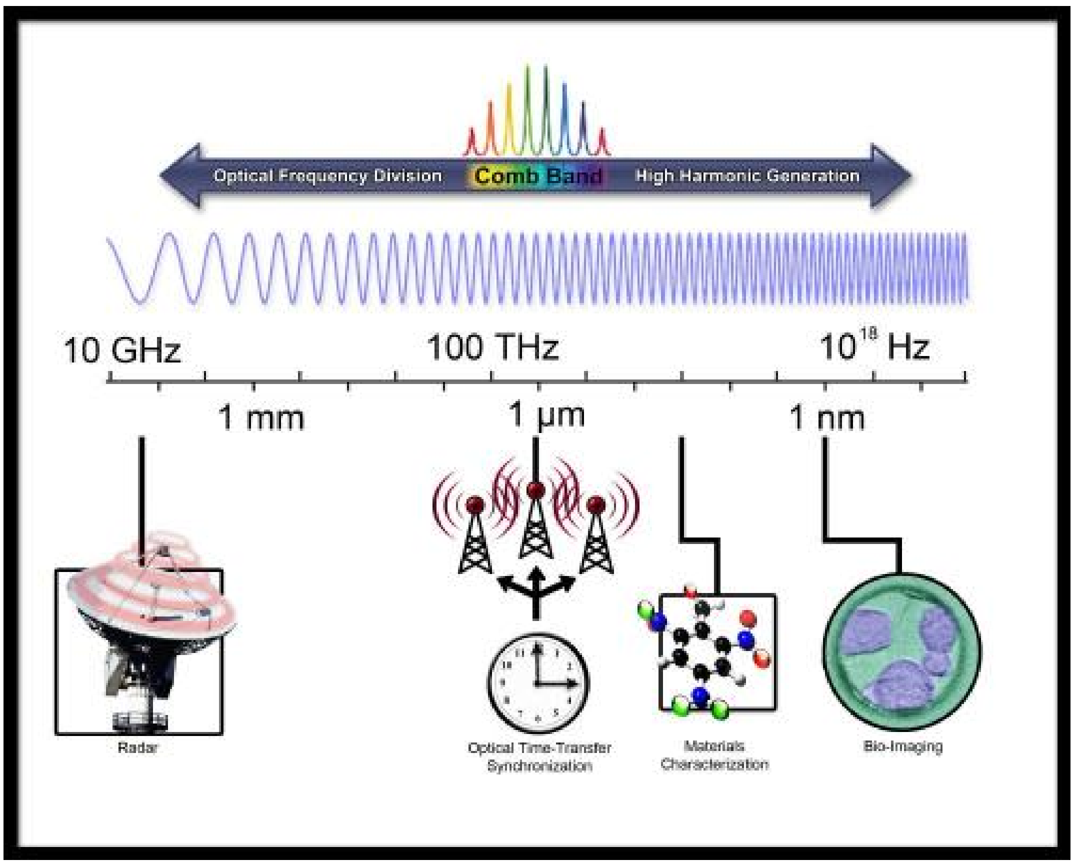

A Navy ship at sea is surrounded by water, with nothing but its carrier group in site, and searches the skies for activity overhead. Isolated radars on each ship in the group scan independently of each other with limited effectiveness. But consider if all of the ships' radars could be coherently linked to function as one. Such a capability would improve the range and resolution of each radar system, making it possible to identify and characterize objects further away and with greater fidelity.

Conventional X-ray machines provide images of bones and organs that help doctors make crucial decisions regarding patient care. They cannot, however, resolve structures at the cellular level. Imagine having access to a table-top x-ray imager that could not only image a single cell, but also the nucleus, ribosomes and other components that make it up; and not only as a flat image, but in 3-D. Such information would be invaluable for testing responses to candidate drugs and discovering new treatments.

These two very different applications are not science fiction and could be enabled by the same basic technology: ultrafast, pulsed lasers operating at optical wavelengths.

These kinds of pulsed lasers are known as frequency combs because they are composed of thousands of individual laser lines, equally separated in frequency like the teeth of a comb. DARPA seeks to control the entire electromagnetic spectrum by using frequency combs to generate and engineer waves in the optical domain and then down or up-convert those waveforms to the desired wavelength. Such technology has many potential applications relevant to the Department of Defense (DoD), such as low phase noise microwave oscillators for secure communications, explosive and chemical agent detection, and the production of attosecond (10-18s) pulses for imaging the motion of electrons in complex materials.

Many of the techniques that underlie these applications have been demonstrated, but are currently unsuitable for practical use because they are restricted to a laboratory setting. DARPA’s Program in Ultrafast Laser Science and Engineering (PULSE) aims to enable synchronization, metrology and communications applications for DoD by advancing compact, high power and environmentally insensitive frequency comb technology, as well as the science underlying these applications. Achieving these goals will require input from researchers across a broad spectrum of disciplines. Potential proposers are encouraged to review and respond to the PULSE Broad Agency Announcement (BAA).

"PULSE is a basic research program initially focused on component technology. Our primary concern isn't demonstrating a specific application, rather making these tools a reality at a practical scale by overcoming current obstacles like size and thermal management," said Jamil Abo-Shaeer, DARPA program manager for PULSE. "The range of potential applications is enormous. Literally any technology that uses electromagnetic radiation could be impacted."

Low phase noise microwave oscillators represent one potential application of the high frequency stability provided by optical frequency combs. Under PULSE, DARPA will pursue enabling technologies to reduce comb size. One possible approach involves recently demonstrated, chip-based optical frequency combs that were generated from micron-scale optical resonators. However, while such combs potentially offer a vast reduction in form-factor compared with conventional technology, they have yet to demonstrate the stability and bandwidth required for low phase noise microwave oscillator production.

At the other end of the spectrum, PULSE will explore how to capitalize on the high intensity obtainable from pulsed lasers for applications like x-ray imaging. PULSE aims to enhance the capabilities of tabletop, high-peak power, pulsed-laser driven x-ray generation techniques; these sources should produce high flux, coherent x-rays with wavelengths in the water-window (2.3 to 4.4 nm) for biological imaging applications. At present, these types of x-rays can only be generated by a few building-sized machines, thus limiting the range of applications.

More information: As a fundamental research program, PULSE welcomes proposals from U.S. and international researchers and is expected to span over a five year time-scale. For detailed information, please review the BAA at: go.usa.gov/G71 . Proposal abstracts are due by 4:00 PM ET, September 4, 2012. Full proposals are due by 4:00 PM ET, November 3, 2012.

Provided by DARPA