Engineers ride 'rogue' laser waves to build better light sources

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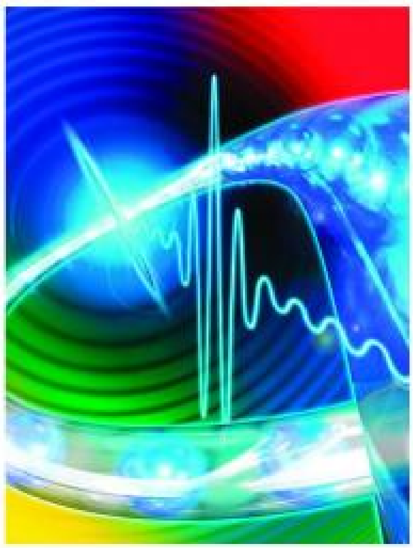

An artist's representation of a rogue wave appearing during supercontinuum generation. Credit: UCLA

A freak wave at sea is a terrifying sight. Seven stories tall, wildly unpredictable, and incredibly destructive, such waves have been known to emerge from calm waters and swallow ships whole. But rogue waves of light -- rare and explosive flare-ups that are mathematically similar to their oceanic counterparts -- have recently been tamed by a group of researchers at the University of California, Los Angeles (UCLA).

UCLA's Daniel Solli, Claus Ropers, and Bahram Jalali are putting rogue light waves to work in order to produce brighter, more stable white light sources, a breakthrough in optics that may pave the way for better clocks, faster cameras, and more powerful radar and communications technologies. Their findings will be presented during the Optical Fiber Communication Conference and Exposition/National Fiber Optic Engineers Conference (OFC/NFOEC), taking place March 22-26 in San Diego.

Rogue bursts of light were first spotted a year ago during the generation of a special kind of radiation called supercontinuum (SC). SC light is created by shooting laser pulses into crystals and optical fibers. Like the incandescent bulb in a lamp, it shines with a white light that spans an extremely broad spectrum. But unlike a bulb's soft diffuse glow, SC light maintains the brightness and directionality of a laser beam. This makes it suitable for a wide variety of applications -- a fact recognized by the 2005 Nobel Prize in Physics, awarded in part to scientists who used SC light to measure atomic transitions with extraordinary accuracy.

Despite more than 40 years of research, SC light has proven to be difficult to control and prone to instability. Though rogue waves are not the cause of this instability, the UCLA researchers suspected that a better understanding of how noise in SC light triggers rogue waves could improve their control of this bright white light. Rogue waves occur randomly in SC light and are so short-lived that the team had to employ a new technique just to spot them. Although they are rare, they are more common than would be predicted by a bell curve distribution, governed instead by the same "L-shaped" statistics that describe other extreme events like volcanic eruptions and stock market crashes.

By tinkering with the initial laser pulses used to create SC light, Solli and his team discovered how to reproduce the rogue waves, harness them, and put them to work. His results, to be presented at OFC/NFOEC 2009, demonstrate that a weak burst of light, broadcast at the perfect "tickle spot," produces a rogue wave on demand. Instead of disrupting things, it stabilizes SC light, reducing fluctuations by at least 90 percent. The seed wave also decreases the amount of energy needed to produce a supercontinuum by 25 percent. The process, says Solli, is similar to boiling water. "If you heat pure water, it can boil suddenly and explosively," he says. "But normal water has nucleation sites for bubble formation that -- like our seed waves stimulate the supercontinuum -- help the water boil smoothly with less heat."

This new-and-improved white light, funded by DARPA, could help to push forward a range of technologies. Solli and Jalali are developing time-stretching devices that slow down electrical signals; such devices could be used in new optical analog-to-digital converters 1,000 times faster than current electronic versions. These converters could help to overcome the current conversion-rate bottleneck that holds back advanced radar and communication technologies. Stabilized SC light could also be used to create super-fast cameras for laboratory use or incorporated into optical clockworks.

Source: Optical Society of America

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