New Technology Makes Possible Mars Webcam, Battlefield Lasers

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It would be a planetary scientist's dream to peer through the eyes of a distant rover's lenses in real-time, looking around an alien landscape as if she were actually on the planet's surface, but current radio transmitters can't handle the bandwidth necessary for a video feed across several million miles. New technology recently patented by scientists at the University of Rochester, however, may make applications like a Mars video feed possible, using lasers instead of radio technology. Special gratings inside the glass of a fiber laser virtually eliminate detrimental scattering, the main hurdle in the quest for high-powered fiber lasers.

"We use lasers in everything from telecommunications to advanced weaponry, but when we need a high-powered laser, we had to fall back on old, inefficient methods," says Govind Agrawal, professor of optics at the University of Rochester. "We've now shown an incredibly simple way to make high-power fiber lasers, which have enormous potential."

By removing one of the main limitations of fiber lasers and fiber amplifiers, Agrawal has allowed them to replace traditionally more powerful, but less efficient and poorer quality, traditional lasers. Currently, industries use carbon dioxide and diode-pumped solid-state crystal lasers for welding or cutting metal and machining tiny parts, but these kinds of lasers are bulky and hard to cool. In contrast, the newest alternative, fiber lasers, are efficient, easy to cool, more compact, and more precise. The problem with fiber lasers, however, is that as their wattage increases, the fiber itself begins to create a backlash that effectively shuts down the laser.

Agrawal worked on a way to eliminate the backlash caused by a condition called stimulated Brillouin scattering. When light of high enough power travels down a fiber, the light itself changes the composition of the fiber. The light waves cause areas of the glass fiber to become more and less dense, much as a traveling caterpillar scrunches up and expands its body as it moves along. As the laser light passes from an area of high density to one of low density, it is diffracted the same way the image of a straw bends as it passes between the air and water in a glass. As the power of the laser increases, the diffraction increases until it is reflecting much of the laser light backward, toward the laser itself, instead of properly down the fiber.

In a discussion with, Hojoon Lee, a visiting professor from Korea, Agrawal wondered if gratings etched inside the fiber might help stop the reflection problem. The gratings can be designed to act as a kind of two-way mirror, working almost exactly the same way as the initial problem, only reflecting light forward instead of backward. With the new, simple design, the laser light fires down the fiber through the gratings, and some of it again creates the density changes that reflect some of the light backward—but this time the series of gratings simply bounces that backward reflection forward again. The net result is that the fiber laser can deliver higher wattages than ever before, rivaling conventional lasers and making possible applications that conventional lasers cannot perform, such as high-bandwidth laser communication with a planetary rover several million miles away.

As a laser beam travels between planets, it spreads out and diffracts so much that by the time a beam from Mars reaches us, its width would be larger than 500 miles, making it incredibly difficult to extract the information encoded on the beam. A fiber laser, with its ability to deliver more power, would help by giving receiving stations a more intense signal to work with. In addition, Agrawal is now working with NASA to develop a laser communications system that would spread less to begin with. “It’s our hope that instead of having a beam that spreads out 500 miles, maybe we can get one that only spreads out a mile or so,” says Agrawal. That concentration of the laser’s power would make it much easier for us to receive high-bandwidth signals from a distant rover.

Many people are using fiber lasers to replace conventional lasers, from the military to the University of Rochester’s own Omega laser in the Laboratory for Laser Energetics (LLE), which is the most powerful ultraviolet laser in the world. Agrawal will be working with scientists at LLE to possibly implement the new grating system into the Omega’s new fiber laser system.

Source: University of Rochester

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