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public information group

news release

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There's new light at the end of the tunnel for some laser-based technologies

LOS ALAMOS, N.M., Aug. 19, 1996 - Scientists at Los Alamos National Laboratory are wondering what light through yonder window breaks. It is a new form of laser light travel that could create important new laser-based technologies and revolutionize some older ones.

Researchers Xin Miao Zhao, David Funk, Charlie Strauss, Toni Taylor and Jason Jones experimenting with a powerful infrared titanium-sapphire laser found that when a light pulse intensity reaches a critical value, the beam focuses itself into a thin filament without the aid of focusing lenses or mirrors and perpetuates itself for long distances.

The beam - two to three times the thickness of a human hair - propagates virtually indefinitely through air without spreading, something conventional lasers cannot do.

In a very simplistic way, the new discovery is similar to a flashlight that shines for an indefinite distance without a focusing, parabolic mirror behind the bulb; beams from both flashlights and ordinary lasers fan out as the light gets farther from the source.

The beam seems to lack the defining characteristics of ordinary light wave propagation: dispersion, diffraction and normal scattering. While the beam still experiences all three physical phenomena, researchers believe that the intense laser light self-compensates and becomes trapped in three dimensions. Because of the intensity of the beam, nonlinear effects compensate for each other giving the appearance that there is no dispersion, diffraction or scattering.

Nonlinear effects of light were first studied in the early 1960's with the invention of the laser. Early laser researchers noticed that laser light did not always behave as predicted, in a linear way where output is a simple mathematical function of the input. For example, twice the amount of input equals twice the amount of output.

Since that time, scientists have learned that light waves can interact in a nonlinear fashion to generate new colors, ionize atoms and molecules, and self-focus. In this nonlinear system, the light wave is more complex because there is a balance between nonlinear processes that keeps the filament trapped.

Light can change the media through which it passes that in turn will change the light. An example is called a thermal lens. The air in the center of a laser beam is hotter than the edges. The air expands and the lower air density in the center acts like a lens, causing the beam to spread out faster than normal.

At the higher intensities of the Los Alamos laser, however, more nonlinear processes appear to be acting to stabilize the competing forces and confine the beam.

"This is the marvelous and unexpected new regime that we are exploring," Strauss said. "The beam appears to be confined in all three dimensions in a magical combination of nonlinear processes that are self-stabilizing, and it all happens in the ordinary atmosphere."

Researchers believe the newly discovered light travel works because it so intense and small. The center of the laser creates a plasma and travels faster through the plasma than light travels in air. The packets of light that are on the fringe of the center eventually feed into the confluence and the beam becomes self-perpetuating.

One of the most unique applications of the discovery is its potential use as a powerful laser lightning rod. Zhao, working with Jean Claude Diels at the University of New Mexico, conducted research into developing a laser to trigger controlled lightning flashes while studying for her doctorate. Zhao says this laser shows great promise for initiating controlled lightning strikes where others have failed.

In the United States, lightning kills 500 people a year and strikes somewhere in the states nearly 15 million times. Lightning makes golf one of the deadliest sports in America. Lightning accounts for up to two-thirds of the power failures and costs American power companies $100 million in damage.

The idea of using lasers as lightning rods is not new, according to Zhao, but previous trials were unsuccessful because conventional laser beams would not travel from ground to cloud, and the plasma created by the beam actually absorbed the laser light. The conventional laser beam also took too much time to form a conductive path, not fast enough for the uncontrolled lightning strike.

The newly discovered form of light travel in the Los Alamos laser shows great promise in overcoming past lightning trigger failures, Zhao says, because the beam can travel such long distances with little degradation. The laser forms a thin tunnel of ions, charged atoms or molecules whose electrons are stripped off by the beam. The ion tunnel attracts the lightning, drawing it away from power plants, air traffic control buildings, or any facility and equipment that needs to be protected.

The self-focusing laser light filament could also revolutionize the light detection and anging technologies, or LIDAR, that have already become prolific in industry, according to the researchers.

LIDAR uses laser light in much the same way that sonar uses sound. A pulse of laser light is emitted into the air, some of that light comes back in the form of backscatter, reflected off particles in the air. The backscatter is collected and analyzed by a computer that counts the number of returned photons, which can then be used to draw conclusions about air quality.

LIDAR has been successful in measuring ozone, aerosols and air pollution, but has several limitations.

LIDAR receives only a small amount of light from the backscatter and the beam's distance is limited. The aim of LIDAR cannot be specific. As the beam leaves the instrument, it disperses and the spot size becomes larger with distance and cannot be focused on a small or very specific target.

The new filament phenomenon may overcome these limitations, researchers say. Light can be sent out in beams finer than conventional LIDAR, and the returning light travels directly back down the beam path instead of being dispersed.

The beam's intensity and self-focusing ability allows it to travel farther than LIDAR and researchers believe they can tune the laser to travel even greater distances by "chirping" the beam. This is a process that allows laboratory scientists to determine where the beam starts to self-focus by controlling the synchronicity of the wave lengths.

"It's like a relay race in a track and field event," Strauss explains. "You start the runners on the inside lanes farther back and the ones on the outside lanes further up the track. Where the runners eventually meet would be where the beam becomes self-focused. With our laser, the inside lane is blue light and the outside lane is red light."

The research has been funded by the Laboratory Directed Research and Development Program.

LDRD is a Congressionally authorized program at Los Alamos. Laboratory management can direct up to 6 percent of incoming programmatic dollars to fund employee-initiated, innovative research that enhances the science and technology capabilities of the Laboratory

The researchers are also looking for industrial partners to develop the technology.

Los Alamos National Laboratory is operated by the University of California for the U.S. Department of Energy.

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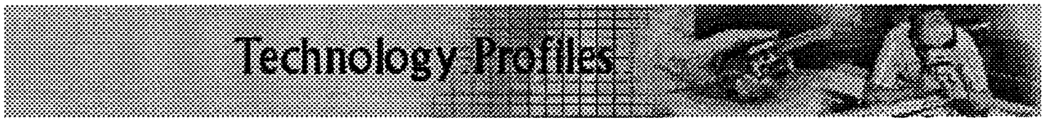
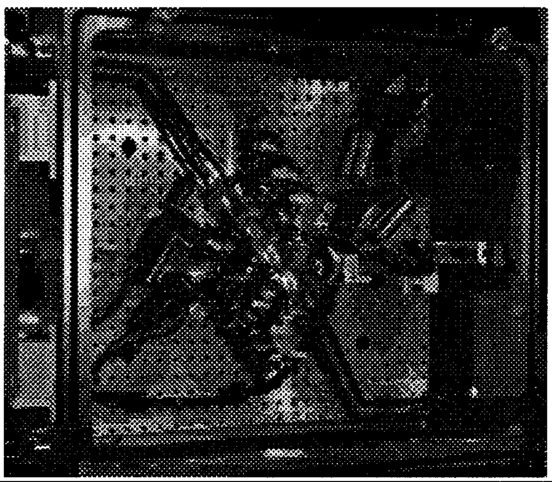


High-Average-Power Titanium:Sapphire Laser

LLNL design offers exceptional beam quality, high power, and broad tunability



LLNL's titanium:sapphire laser operates for hundreds of hours at a time, with high reliability and minimum attention.

The Isotope Separation and Advanced Manufacturing (ISAM) Technologies program at LLNL has developed the world's highest average power titanium:sapphire laser. It can produce more than 50 watts of tunable output in a diffraction-limited TEM00 mode beam. At these power levels, the tuning range of this laser is from 650 nm to more than 1000 nm, greater than that of any available titanium:sapphire laser.

APPLICATIONS

- Precision materials processing
- Enriching medical isotopes
- X-ray lithography
- Polarized-ion source for research accelerators
- Beaming power to satellites

High reliability

Our titanium:sapphire laser has an exceptional combination of excellent beam quality, high power, and broad tunability. This has been achieved with a patented design that takes advantage of the unique high-thermal-conductivity of sapphire at low temperatures, combined with a special multi-rod resonator for power scaling. This laser can be pumped with cw argon-ion, pulsed-copper, or frequency-doubled Nd:YAG lasers. Our titanium:sapphire laser has regularly operated for hundreds of hours at a time, with high reliability and minimum attention, in an industrial environment during isotope-enrichment demonstrations.

Precision materials processing

The excellent beam quality of our titanium:sapphire laser in pulsed operation makes it well suited for precision laser materials processing. Other potential applications include enriching stable medical isotopes (such as Carbon 13, Oxygen 18, and Strontium 88), beaming power to satellites, and generating soft x-rays for x-ray lithography.

Our laser design has produced more than one watt of continuous-wave, frequency-doubled coherent light. Indeed, a much higher second-harmonic power output is expected when the system is optimized and used in the pulsed mode. High-average-power, mode-locked operation should also be possible with this laser. Because of its high-power output, our titanium:sapphire laser design is regarded as the laser of choice for the polarized-ion source at the Los Alamos Meson Physics Facility (LAMPF), and other accelerators throughout the world.

Availability: This patented technology is available now. LLNL is seeking industrial partners to commercialize the laser and its applications.

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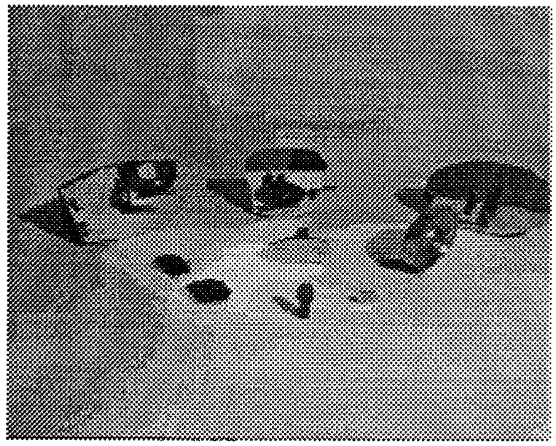
The Industrial Partnerships and Commercialization Office at Lawrence Livermore National Laboratory invites industries to explore the possibility of a match between their technological needs and our Laboratory's multidisciplinary capabilities. Our specialists know how to connect industry representatives with researchers in their field of interest. To start, simply complete our Company Contact Form.

HARDRIC LABORATORIES, INC.

Hardric Laboratories, Inc.

Celebrating 45 years of Precision Machining and Optics



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Talk to Us

Since its founding in 1954, Hardric Laboratories, Inc has been a pioneer in the field of ultra-close tolerance machining. We have made components from a wide range of unusual metals, glass and ceramics for commercial and military applications all over the world. These include aerospace, optics, guidance systems, night vision, medical technology, computers, electronics, laser welding and laser engraving.

The Metal Optics Group, founded in 1980, is a World Leader in Beryllium Optics and offers HardZap™ beryllium mirrors for scanning, night vision and other applications. In 1992 diamond-turning capability was added allowing us to offer electroless-nickel coated beryllium optics as well as diamond-turned aluminum, brass, etc. mirrors.

Our small, elite staff of highly skilled experts will work closely with your designers and engineers to assure the highest quality, the most efficient manufacturing and on-time delivery.

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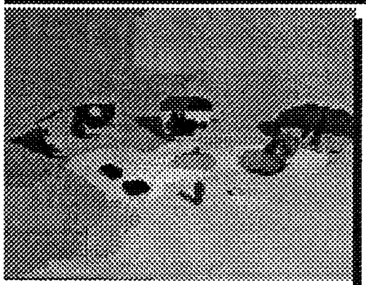
Should you have questions or problems concerning this web site, please e-mail the Webmaster at webmaster@hardric.com or submit the form at "Talk to Us."



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HardZap™ Beryllium Optics are used in scanning, night vision and other applications. These mirrors are made of bare-polished beryllium metal (i.e. no electroless nickel coating) and so do not exhibit the bi-metallic problems associated with the traditional electroless nickel coated beryllium mirrors. Their light weight, extreme stiffness, and excellent heat tolerance have made them a standard for fast and highly accurate scanning systems.

HardZap mirrors can be coated with a variety of evaporated coatings to provide/enhance reflectivity at most wavelengths in the IR, visible and UV.

Applications -----------------

Laser cutting
Laser welding
Laser Etching
Inspection
Cameras
Rapid-Prototyping

Capabilities:

FLATNESS: We have achieved better than 1/10 lambda at 633 nm. However, our ability to achieve this depends on the mirror size and design and will increase the cost of the mirror. So specify only the flatness your application requires.

SURFACE FINISH: Depending on the size of the mirror, we have achieved better than 15 Angstroms RMS on the bare beryllium. If you need this fine a finish, review your mirror design with our engineering staff.

MIRROR SIZE: Up to 18 in. (45.7 cm) across.

COATINGS: Our standard coatings are gold, enhanced gold, silver, enhanced silver (Request our reflectivity chart). Coatings for use with high-power CO_2 and YAG lasers are available. Other coatings on request.

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