Lawrence Livermore National Laboratory

2011 R&D 100 Award Winner

Glimpsing Fusion with the World's Fastest Light Deflector

The serrated light illumination for deflection-encoded recording (SLIDER) is the world's fastest deflector. When mated to an ordinary camera, it can record optical signals on picosecond (trillionth of a second) timescales. When combined with a high dynamic range camera, SLIDER can maintain this temporal resolution and a high dynamic range—two performance parameters that are difficult to meet simultaneously. This unique combination of high resolution and dynamic range will be crucial for better understanding reactions that occur under the extreme conditions needed for the tritium–deuterium fuel in a National Ignition Facility target to "ignite" and then undergo thermonuclear burn.

The SLIDER development team: (from left) Susan Haynes and John Heebner.

Overcoming Limitations of Existing Technologies

While the signals from fusion reactions are too fast to be recorded by conventional electronic instruments, they are also too slow for spectral techniques now being used in ultrafast laser physics with characteristic timescales of femtoseconds. SLIDER complements existing technologies and bridges the gap between conventional streak cameras and spectral-based ultrafast recording techniques. This optical version of the streak camera has the capability of deflecting light rapidly enough to achieve picosecond resolution.

It's All in the Prisms

At the heart of SLIDER lies a solid-state optical deflector that rapidly activates an array of prisms for each sweep repetition. The signal to be recorded rides on a beam of light sent through a semiconductor planar waveguide. A pump laser directed in from above rapidly modifies the waveguide's optical properties. The pump beam is first passed through a serrated mask just above the waveguide. While the signal is traversing the waveguide, the patterned pump beam imprints an array of more than 100 prisms. Because the earlier portions of the signal have advanced farther along the waveguide at the moment of prism creation, they are deflected the least. The later portions, however, see more activated prisms and are hence deflected the most. This sweeping beam is then collected and focused by lenses for recording on a conventional camera. In addition to its application in fusion energy science, SLIDER might be used to characterize high-bandwidth, long-haul telecommunication systems; chemical reactions; particle accelerators; and short-pulse lasers.

Chris Sarantos

Signals to be recorded propagate from left to right in a thin waveguide layer at the top of the serrated light illumination for deflection-encoded recording (SLIDER) system's deflector. The pump beam illuminates the top of the device where the serrated gold mask defining the prisms resides. The deflected beam emerging from the device is collected and focused by a lens onto a camera for recording.

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