Trillion-Watt Laser Pulse Frozen in Single Shot by Scientists

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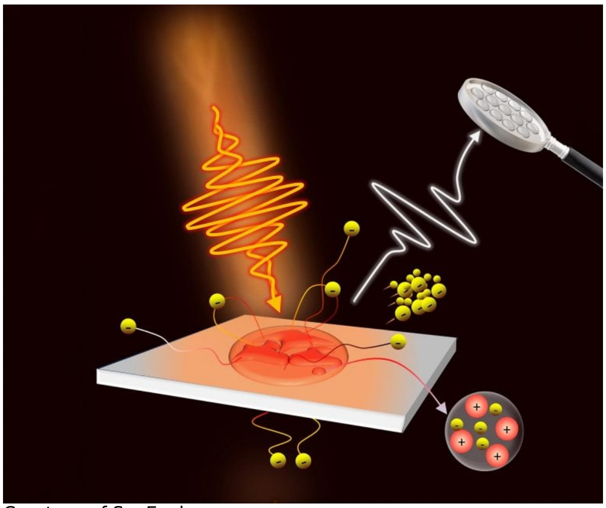

Courtesy of SynEvol
Credit: Ankit Dulat

Scientists at the Tata Institute of Fundamental Research (TIFR) in Mumbai have created a new technique to precisely measure ultrashort, ultrahigh-power laser pulses. Their results appeared in Optica, a prominent open-access journal in the optics domain.

What is the significant advancement?

Lasers represent a pivotal technology of the modern era, enabling the generation of ultrashort optical pulses with durations among the shortest achievable. Notably, these pulses can exhibit exceptionally high peak power, exceeding global electrical power consumption by several orders of magnitude.

In this domain, optics has transformed into a contest of immense influence.

Nonetheless, quantifying the accurate time structure, or temporal profile, of these laser pulses poses a significant challenge. Despite the advancements in techniques by scientists in recent decades, several significant issues persist.

A significant problem is that as these intense pulses travel through any substance, their timing may get distorted. The stronger the pulse, the larger the distortion.

Another significant complication relates to the pulse time profile varying at different locations within the laser beam itself. Typically, scientists might overlook these variations throughout the beam's spatial extent and presume a uniform temporal profile. Nevertheless, as the beam size increases and/or the distance it travels through a medium grows, these distortions become increasingly significant, dramatically altering the pulse. At ultrahigh peak powers, it is essential to understand the time duration at various locations throughout the spatial range of the beam.

The TIFR team employed a uniquely crafted device to assess the time profiles at various spatial locations within the ultrashort laser beam. They employed an optical method called ‘spectral interferometry’ at various locations across the beam at the same time to accomplish this. The team worked together with Umea University in Sweden on this research.

As the scientific community progresses towards laser powers unprecedented in history (hundreds of thousands of trillion watts!) within beams that span diameters of several tens of centimeters, this approach will prove to be not only highly beneficial but crucial.

Here is another uplift for this approach. These ultrahigh power lasers release pulses occasionally – once over several seconds/minutes/hours. The previous measurement methods required sampling numerous pulses before assessing the pulse profile, which will be very tedious.

The TIFR progress addresses this as well. It functions for one pulse! Now, the finishing touch. As peak laser powers soar, conventional solid optical components cannot manage them as they fail due to ionization. Consequently, the technology is advancing towards utilizing ionized matter or 'plasma' to create these optical components. These plasmas can be very unstable and lead to additional distortions in the spatiotemporal characteristics of the incident pulse. The TIFR approach is ideally designed to assess these distortions.