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A Review on Laser light emission and AI -Industrial revolution

[1]Jyothi Budida, , [2] Dr. Kamala Srinivasan

[1]Faculty Department of Physics, Aditya College of Engineering, Surampalem, A.P, India.

jyothi_bse@acoe.edu.in

[2]Academic consultant, Department of Physics , Sri Venkateshwara University, Tirupati

kamalasrinivasan@rediffmail.com

ABSTRACT

Laser light made its revolution in technology with its potential applications combined with AI. The emission of XUV radiation makes their simulations has a unique and interesting property .The nineteenth-century industrial revolution, powered by water and steam, saw a giant leap forward in manufacturing and mass production. A second technological jump came through harnessing electricity, while computers and digital innovation enabled a third. The fourth industrial revolution is now underway with the combination of digital and physical technologies to allow production and control on demand: an industrial internet of things.

By using artificial intelligence (AI) to better understand the complex physics underlying the way lasers cut, weld or drill materials, these researchers hope to make possible internet-based control of laser production systems, so that we can manufacture the things we want, on-demand, from home.

INTRODUCTION

The term "LASER" is an acronym for Light Amplification by the Stimulated Emission of Radiation. The unique properties of laser light such as coherence, directionality, and narrow frequency range are the key advantages used in laser applications. Based on the type of lasing mediums, there are several types of lasers namely solid state lasers, gas lasers, dye lasers and semiconductor lasers.
Today, lasers are being used in many different applications while more new applications are being developed.

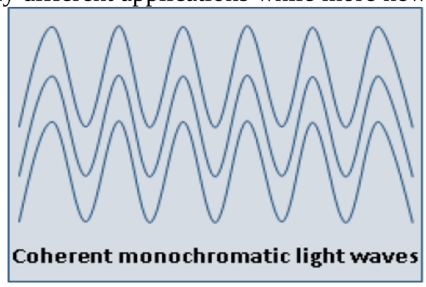

Fig 1 : Coherent monochromatic light waves

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Ordinary light is used in lighting a small area. (Where divergence of the light sources is very important). Laser light is used in eye surgery, tattoo removal, metal cutting machines, CD players, in nuclear fusion reactors, laser printing, barcode readers, laser cooling, holography, fiber optic communication, etc. Ordinary light cannot be focused to a sharp spot as ordinary light is divergent. Laser light can be focused to a very sharp spot as laser light is highly directional.

Interactions between intense laser pulses and plasma mirrors have been the focus of several recent physics studies due to the interesting effects they produce. Experiments have revealed that these interactions can generate a non-linear physical process known as high-order harmonics, characterized by the emission of extreme ultraviolet radiation (XUV) and brief flashes of laser light (i.e., attosecond pulses).

Researchers at The Extreme Light Infrastructure ERIC in Czechia and Osaka University in Japan recently uncovered a surprising transition that takes place during interactions between intense laser pulses and plasma mirrors. This transition, marked by an anomalous emission of coherent XUV radiation, was outlined in a paper published in *Physical Review Letters*.

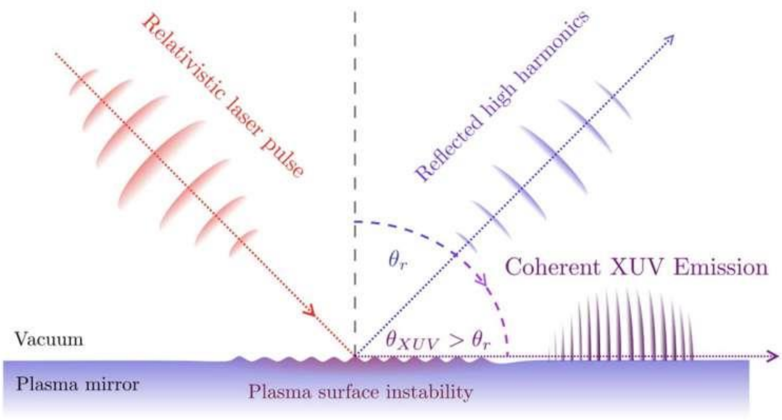

Fig2 : Transitions of LASER marked by ERIC in Czechia and Osaka University in Japan

LASER VERSATILITY

Since their development in the 1960s, lasers have offered exciting manufacturing possibilities. The applications are diverse and their properties are near perfect. They can focus a lot of optical energy on a small spot, generating a great deal of heat at a precise point on a target. So, unlike many conventional mechanical and chemical industrial process, laser processing is super-efficient and doesn't require any additional chemicals.

Lasers can be pulsed at extraordinary rates, and the duration of each pulse can be as short as a few tens of femtoseconds (10^{-15} seconds). This is faster than rate that energy can dissipate, allowing for microscopic processing of materials at scales of less than a millimetre, without causing heat damage. And with the correct choice of laser wavelength, the light can destroy one type of material, while leaving others intact.

Furthermore, laser power can be used in a blunt way, such as welding parts together, cutting sheets of metal or drilling holes. Or lasers can be applied more subtly, such as to polish or texture a surface.

XUV Emission

Specifically, the researchers found that this coherent radiation propagates in parallel to the surface of the plasma mirror. Further calculations linked this anomalous emission to laser-driven oscillations of relativistic electron nanobunches originating from the instability of the plasma's surface.

"We believe that there is an interesting potential in potentially controlling this mirror self-modulation, where enhanced coherence could be achieved for more narrow-band coherent XUV generation in the initial stages of the surface instability," Lamač added.

This recent work by Lamač and his collaborators gathered new insight into the physical processes arising from the interaction between intense laser pulses and plasma mirrors. The results of the researchers' simulations could soon pave the way for more studies exploring the anomalous emission they observed, potentially leading to new interesting discoveries.

HIGH-QUALITY DATA

Because lasers are electrically driven, they are easier to integrate into computer-control systems, making them ideal for cyber-physical systems. But the array of laser properties that make this wide range of applications possible.

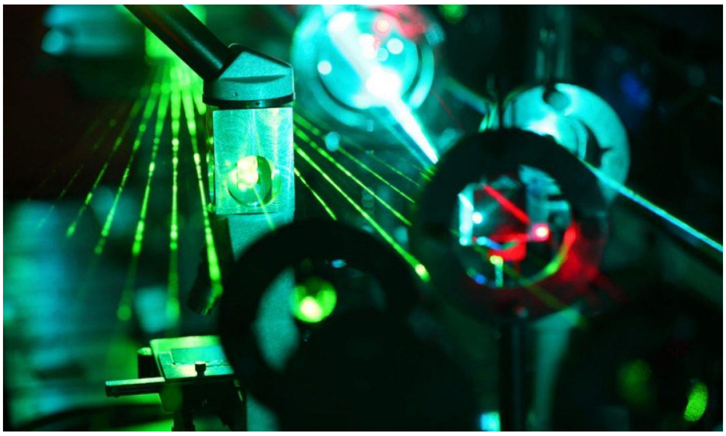

Fig 3: Laser multiple beams-AI

Using multiple high-energy laser beamlets, researchers in Japan were able to accelerate electrons more efficiently.

Traditionally, the solution would be user intuition based on trial and error, but optimizing a laser system in this way can take months, which is simply not viable at the scale required to realize truly useful cyber-physical systems. To complicate matters further, even when the best configuration is identified for a specific system to perform a specific task, what works well for one type of material might not work for another.

High-quality data is crucial because AI machine-learning systems need to be trained. The researchers have applied their idea to many laser production processes including, very recently, laser ablation: using a short pulse of light to remove a small amount of material from a surface. In this case, they created a high-quality dataset by firing light pulses of controllable duration at a solid target. A three-dimensional microscope then provided images for the corresponding surface changes at a rate of about one per minute, or a 1,000 data points in a day. This big-data driven approach is proving very fruitful, and the University of Tokyo collaborators at Kyushu University in Fukuoka are already exploiting the method to serve the semiconductor manufacturing industry.

Conclusion

The interaction between light and matter at such high intensities is complex. The physics of laser ablation, for example, needs further clarification before it is completely understood. The strength of the electric field at the focus of the laser can be akin to that holding an atom together, so simple models based on melting and vaporization are of little use. Sophisticated molecular dynamic simulations offer hope, but the processing power required is immense because the physical processes that take place during laser ablation are so varied — the laser pulses are as fast as a few femtoseconds, while melting might take place over microseconds.

By using XUV emission of Laser light with AI, it creates new avenues to research, which will make a new era in technological applications.

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