frontiers | Frontiers in Physics

TYPE Editorial
PUBLISHED 18 November 2022
DOI 10.3389/fphy.2022.1052461

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Optics and Photonics,
a section of the journal
Frontiers in Physics

RECEIVED 24 September 2022
ACCEPTED 07 November 2022
PUBLISHED 18 November 2022

CITATION
Fu X, Euser T, Huang S-W, Joly NY and Xie S (2022), Editorial: Future directions in novel laser source development: Dynamical properties, and beam manipulation.
Front. Phys. 10:1052461.
doi: 10.3389/fphy.2022.1052461

Editorial: Future directions in novel laser source development: Dynamical properties, and beam manipulation

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KEYWORDS

laser source, beam manipulation, laser application, laser dynamics, novel laser development

Editorial on the Research Topic
Future Directions in Novel Laser Source Development: Dynamical Properties, and Beam Manipulation

Lasers, which are ubiquitous in everyday life, have revolutionized the world in the fields of manufacturing, communication, metrology, sensing, display, directed energy, and others. Tremendous technological breakthroughs in laser sources have been reported to meet the ever-increasing demands for improved laser performance [1]. Today, new trends for laser development are emerging, including advanced laser sources with specially tailored attributes (such as spatial patterns, spectral properties, pulse shapes, wavelength coverage, etc.). A variety of laser applications has called for these new sources. As a result, remarkable progresses have been made in this direction over the past decades.

Complete characterization and control of laser outputs among multiple domains and degrees of freedom is the key for practical laser-matter interactions. In this context, better control over laser properties has a vast range of new laser application scenarios, such as: adapting spatial beam profiles to achieve super-resolution imaging of living cells [2], tailoring pulse shapes and wavelength range to generate optical frequency rulers with unprecedented precision [3], employing the angular momentum of laser beams to realize contactless and multi-dimensional motion control of nano-particles [4], to name a few. In addition, recent technological progress has created new paradigms, such as on-chip lasers and photonics [5], metasurface lasers [6], topological lasers [7], biological lasers [8],

and air lasing [9], offering abundant dynamics and enabling applications to be explored. The goal of this Research Topic is to take a snapshot of the current frontier of dynamics and manipulation of novel laser sources. Furthermore, we aim to build connections between experts from different backgrounds to gather the current state-of-the-art and to ensure that researchers in distinct sub-areas can learn from each other's progress.

This Research Topic includes thirteen original research articles covering the laser sources, beam manipulation and applications. At the cutting edge of newly developed lasers, Wang et al. demonstrated the broadest tuning range of the femtosecond Cr:ZnSe/ZnS lasers, which may be applied to medical diagnostics and molecular spectroscopies. Zhang et al. reported the generation of the 335.5 nm wavelength laser based on a home-built resonant cavity, having a high-peak-power density up to 20.86 MW/cm^2. The source is ready for the generation of narrow-linewidth 167.75 nm vacuum ultraviolet (VUV) single-frequency continuous wave (CW) laser, towards angle-resolved photoemission spectroscopy (ARPES) with high energy resolution. Echarri et al. demonstrated results of photo-ionization experiments driven by a newly developed compact tunable diamond Raman laser. It exhibited comparable performance with commonly used Ti:sapphire lasers in terms of produced ion current. For developing near-infrared high energy laser source, Jiang et al. reported a nanosecond single-aperture Nd:YAG laser producing 10 J energy at the repetition rate of 50 Hz. In addition, Lei et al. introduced hybrid nanosecond laser oscillator and amplifier with gain crystal combination of Nd:YAG and Nd:LuAG, and analyzed the influence of overlapping gain spectra. To obtain multi-beam repetition-rated regenerative amplifiers with high performance, Gao et al. reported the detailed design method, and obtained eight-beam output with uniform energy and high energy stabilities (RMS of 0.3%–0.9%) over 2 hours.

Several authors presented their recent work on beam manipulation and propagation properties of laser beam. Wang et al. studied the distinct characteristics and properties of optical lattice patterns in transverse mode locking (TML) and non-TML states, which can be distinguished by intensity comparison, interferometry, and beat frequency spectrum. Zhang et al. explored the effect of thermal blooming induced by the propagation of higher-order laser mode from fiber array. They investigated the influence of beamlet arrangement on the energy focusability under thermal blooming. Liu et al. reported the propagation properties of a novel twisted Hermite-Gaussian correlated Schell-model beam, as a new type of partially coherent twisted beam. Then they discussed the enhancement on the self-reconstruction capability by the twist phase. Lu et al. studied the behavior of partially coherent beam in nonlinear media, indicating the threshold condition of coherence size related to the self-focusing phenomenon.

Finally, we should remember the famous statement from the early stages of lasers, which was considered a solution looking for a problem [10]. Applications of laser are numerous. For this Research Topic, Wen et al. showed that the advanced laser plasma shockwave cleaning enhanced the fabrication quality of black silicon, which is crucial for large-scale industrial preparation. Liu et al. proposed and verified an augmented reality holographic stereogram, by simultaneously rendering the obtained scene model and virtual scene. Peng et al. demonstrated the imaging through random scatter medium. They carried out the spatial coherence measurement, and reconstructed the image information with the help of iterative phase retrieval algorithm in the Fresnel domain.

In summary, this Research Topic collects a vast range of latest progresses on the novel laser source development, serving as a worth reading reference for the researchers in the related fields.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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