Plasma-Based Soft X-Ray Lasers: from Large Single-Shot Machines to Compact High Repetition Rate Devices Enabling Applications

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Plasma-based soft X-ray lasers (SXRL) enable experiments requiring bright, high energy pulses of coherent soft X-ray radiation to be conducted in compact setups. This talk will review how plasma-based laboratory soft X-ray lasers, which initially started from plasmas generated by high energy pump lasers that could often fire only several shots per day, evolved into high repetition rate table-top devices that enable numerous applications. New excitation schemes such as transient excitation and more efficient plasma heating schemes have allowed a dramatic reduction of the pump energy required to reach gain saturation. However, the development of soft X-ray lasers has also been limited by the available pump source technology. The introduction of direct discharge pumping using capillary discharges and new advances in high energy ultrashort pulse solid-state lasers have made it possible to increase their repetition rate, extend their wavelength range, and generate shorter (ps and sub-ps) pulses. Compact, high power solid-state lasers have enabled the operation of gain-saturated compact repetitive X-ray lasers at wavelengths down to λ=6.85 nm in Ni-like Gd. In turn, the development of Joule-level diode-pumped ultrashort-pulse optical lasers has made it possible to increase the repetition rate of SXRLs to 100 Hz, with, for example, an average power of > 0.1 mW at λ=13.9 nm. Injection seeding with high harmonic pulses has enabled the soft X-ray lasers with practically full spatial and temporal coherence. The application of these lasers in multiple applications affecting several different fields, including dense plasma diagnostics, nanoscale imaging, nanofabrication, photochemistry and photophysics, and nuclear forensic, will be reviewed. Future prospects will be discussed.

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