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Editorial

Ultrashort-Pulse Generation

From Terahertz Frequencies to X-Rays

The last few years have brought about dramatic advances in the physics and technology of ultrashort-pulse generation over a wide range of the electromagnetic spectrum. The primary sources of coherent short-pulse radiation have been passively mode-locked lasers, which emit continuous-wave trains of ultrashort optical pulses in the visible and near-infrared spectral region. More than two decades after the first demonstration of a picosecond mode-locked laser, we have recently witnessed the emergence and evolution of a new generation of ultra-short-pulse lasers based exclusively on solid-state components.

Novel ultrafast optical modulation techniques have been developed and used for passive mode locking of a number of different solid-state laser oscillators. The "self-mode-locked" Ti:Sapphire laser and related solid-state systems have allowed powerful femtosecond-pulse generation with an unprecedented stability, reliability, and reproducibility. Concurrently, "additive-pulse mode locking" of fiber lasers resulted in the most stable and compact ultra-short-pulse sources ever reported.

These advances have led to a revival of the interest in nonlinear optical processes for frequency conversion of ultrashort pulses. The concomittant appearance of high-damage-threshold synthetic nonlinear insulating crystals triggered the development of efficient optical parametric generators and oscillators, as well as harmonic generators, giving rise to a substantial extension of the spectral coverage of ultrashort-pulse sources in the ultraviolet and infrared. Significant progress has also been made in the generation of far-infrared (terahertz) radiation by current surges induced in semiconductors irradiated by short optical pulses. Last but not least, the advent of laboratory-scale terawatt amplifiers based on solid-state or excimer gain media has opened the way towards the efficient generation of short-wavelength radiation well into the X-ray regime.

This feature issue comprises ten invited papers to highlight the remarkable advances that have been made recently in this fascinating field, which continues to grow and is making a major impact on physics, chemistry, biology, materials science, and engineering. We have now arrived at a stage where progress in many areas of science and technology critically depends on the availability of powerful coherent ultrashort optical pulses in different regions of the electromagnetic spectrum. This collection of papers written by leading experts in the individual subfields will serve as a record of the current state-of-the-art, and stimulate researchers to think about how they can benefit from the improved ultrafast-pulse sources and techniques in their own field of research.

Finally, we would like to thank the authors for their excellent contributions and the reviewers for the many helpful comments and their constructive criticisms. We are confident that their efforts will be rewarded by the further expansion of ultrafast-pulse techniques into new areas of science and technology.

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