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# EDITORIAL: Focus on Attosecond Physics

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EDITORIAL

# Focus on Attosecond Physics

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Investigations of light–matter interactions and motion in the microcosm have entered a new temporal regime, the regime of *attosecond* physics. It is a main 'spin-off' of strong field (i.e., intense laser) physics, in which nonperturbative effects are fundamental. Attosecond pulses open up new avenues for time-domain studies of multi-electron dynamics in atoms, molecules, plasmas, and solids on their natural, quantum mechanical time scale and at dimensions shorter than molecular and even atomic scales. These capabilities promise a revolution in our microscopic knowledge and understanding of matter.

The recent development of intense, phase-stabilized femtosecond ($10^{-15}$ s) lasers has allowed unparalleled temporal control of electrons from ionizing atoms, permitting for the first time the generation *and* measurement of isolated light pulses as well as trains of pulses on the attosecond (1 as = $10^{-18}$ s) time scale, the natural time scale of the electron itself (e.g., the orbital period of an electron in the ground state of the H atom is 152 as). This development is facilitating (and even catalyzing) a new class of ultrashort time domain studies in photobiology, photochemistry, and photophysics.

These new coherent, sub-fs pulses carried at frequencies in the extreme ultraviolet and soft-x-ray spectral regions, along with their intense, synchronized near-infrared driver waveforms and novel metrology based on sub-fs control of electron–light interactions, are spawning the new science of attosecond physics, whose aims are to monitor, to visualize, and, ultimately, to control electrons on their own time and spatial scales, i.e., the attosecond time scale and the sub-nanometre (Ångstrom) spatial scale typical of atoms and molecules. Additional goals for experiment are to advance the enabling technologies for producing attosecond pulses at higher intensities and shorter durations. According to theoretical predictions, novel methods for intense attosecond pulse generation may in future involve using overdense plasmas.

Electronic processes on sub-atomic spatio-temporal scales are the basis of chemical physics, atomic, molecular, and optical physics, materials science, and even some life science processes. Research in these areas using the new attosecond tools will advance together with the ability to control electrons themselves. Indeed, we expect that developments will advance in a way that is similar to advances that have occurred on the femtosecond time scale, in which much previous experimental and theoretical work on the interaction of coherent light sources has led to the development of means for 'coherent control' of nuclear motion in molecules.

This focus issue of *New Journal of Physics* is centered on experimental and theoretical advances in the development of new methodologies and tools for electron control on the attosecond time scale. Topics such as the efficient generation of harmonics; the generation of attosecond pulses, including those having only a few cycles and those produced from overdense plasmas; the description of various nonlinear, nonperturbative laser–matter interactions, including many-electron effects and few-cycle pulse effects; the analysis of ultrashort propagation effects in atomic and molecular media; and the development of inversion methods for electron tomography, as well as many other topics, are addressed in the current focus issue dedicated to the new field of 'Attosecond Physics'.

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