Condensed Matter in Ultrafast and Superstrong Fields: Attosecond Phenomena
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We discuss latest developments in theory and recent experimental results for a new class of phenomena in condensed matter optics when a strong optical field \( \sim 1-3 \text{ V/Å} \) reversibly changes the solid within an optical cycle [1-7]. During a single-oscillation of a strong optical pulse, a dielectric undergoes a reversible transition to a semimetallic state, which follows the instantaneous optical field during time intervals on order of hundred attoseconds. Such a pulse drives ampere-scale currents in dielectrics and controls their properties, including optical absorption and reflection, extreme UV absorption, and generation of high harmonics [8] in a non-perturbative manner on a 100-as temporal scale. Applied to a metal, such a pulse causes an instantaneous and reversible loss of the metallic properties. We will also discuss our latest theoretical results on graphene, a semimetal, in a strong ultrashort pulse field [9, 10] revealing unique behavior inherent in graphene. These are fastest phenomena in optics unfolding within half period of light. They offer potential for petahertz-bandwidth signal processing, generation of high harmonics on a nanometer spatial scale, etc.

References