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Condensed Matter in Ultrafast and Superstrong Fields: Attosecond Phenomena

MARK STOCKMAN, Center for Nano-Optics (CeNO) and Department of Physics and Astronomy, Georgia State University, Atlanta, GA 30302

We present our latest results for a new class of phenomena in condensed matter optics when a strong optical field 1-3 V/ changes a solid within optical cycle [1-7]. Such a pulse drives ampere-scale currents in dielectrics and adiabatically 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, potentially, reversible change from the metallic to semimetallic properties. We will also discuss our latest theoretical results on graphene that in a strong ultrashort pulse field exhibits unique behavior [9, 10]. New phenomena are predicted for buckled two-dimensional solids, silicene and germanine [11]. 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.

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