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Graphene in Ultrafast and Ultrastrong Laser Pulses[1] HAMED KOOCHAKI KELARDEH, VADYM APALKOV, MARK STOCKMAN, Georgia State Univ — We have shown that graphene subjected to an ultrafast (near-single-oscillation pulse) and strong (F $\sim$ 1-3 V/Å) pulse exhibits fundamental behavior dramatically different from both insulators and metals. In such an ultrafast and ultrastrong field, the electron dynamics is coherent, in contrast to relatively long pulses (τ>100 fs) where the electron's dephasing becomes important leading to incoherent dynamics. Electron transfer from the valence band (VB) to the conduction band (CB) is deeply irreversible i.e., non-adiabatic, in which the residual CB population (after pulse ends) is close to the maximum one. The residual CB population as a function of wave vector is nonuniform with a few strongly localized spots near the Dirac points, at which the CB population is almost 100%. Furthermore, it is shown the direction of charge transfer depends on the pulse amplitude. Namely, at small pulse amplitude, $\leq$1V/Å, the charge is transferred in the direction of the pulse maximum (positive transferred charge), while at large amplitude, $\geq$1 V/Å, it is in opposite direction of the pulse maximum (negative transferred charge). Consequently, in terms of charge transport, graphene at small pulse intensities behaves as a dielectric while at large intensities acts as a metal. These femtosecond currents and charge transfer in graphene may provide fundamental basis for detection and calibration of ultrashort intense laser pulses and are promising for petahertz information processing.

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