Light-Driven Electron Dynamics in Graphene

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Due to its outstanding electronic properties, graphene is a promising material for future applications in electronic devices. One idea is "valley-tronics", which exploits the valley degree of freedom to selectively change transport properties, requiring a broken symmetry between the K and K' points of graphene. To make this approach feasible for graphene-based systems, we investigate the possibility to break the symmetry of graphene's sublattices by a laser pulse. Using optical Bloch equations and a tight-binding description of graphene, we study the conduction band population in $\mathbf{k}$-space and the residual current generated by a structured laser pulse in finite and infinite graphene sheets. We find that a laser pulse with a trefoil polarization can break the symmetry between the K and K' points. This is reflected in a conduction band population, which is distinctly different for each high symmetry point, and a residual current which depends in direction and magnitude on the orientation of the polarization with respect to the graphene lattice. Furthermore, we investigate the relaxation dynamics caused by the electron-electron interaction, which allows for an identification of time-scales at which the laser-induced asymmetry persists in graphene.