Nonlocal Electrodynamics in Graphene

Presenting Author Meir Lewkowicz[1]
Co-Authors B. Rosenstein[1,2], H.C. Kao[3]

[1]*Ariel University, Ariel 40700, Israel*
[2]*National Chiao Tung University, Hsinchu 30050, Taiwan, Republic of China*
[3]*National Taiwan Normal University, Taipei 11677, Taiwan, Republic of China*

lewkow@ariel.ac.il

Abstract
Graphene, a one-layer-thick hexagonal array of carbon atoms, when undoped, exhibits a curious mixture of properties pertinent to either metals or insulators. On the one hand, despite near absence of both charge carriers and impurities, it has a finite conductivity like a metal. On the other hand, the Coulomb interaction between electrons is unscreened like in a dielectric and hence is long range. The chemical potential is pinned right between the conical valence and conduction bands causing quasiparticles to move like massless relativistic particles. We demonstrate at small coupling that the electrodynamics of graphene exhibits nonlocality on a macroscopic level due to the combination of the long-range interactions and the linear dispersion relation. The frequency and wavevector **k**-dependent conductivity tensor, in addition to a local pseudo-Ohmic part $\sigma_T \delta_{ij}$, possesses a nonlocal contribution $\sigma_{nl} k_i k_j / k^2$. While the coefficient of the local part is $\sigma_T \approx e^2 / 4\hbar$ the coefficient of the nonlocal part is proportional to the Coulomb interaction strength α, $\sigma_{nl} = \sigma_T \alpha$. This leads to several remarkable effects in transport and optical response. In particular, the resistance of the graphene flake depends on the location and the geometry of the source, drain, and probes. A voltage perpendicular to the current appears in a time-reversal symmetric situation and the polarization of reflected and transmitted light is modified, without either the magnetic field (like in the Faraday effect) or anisotropy.[1]

References

[1] B. Rosenstein, H. C. Kao and M. Lewkowicz, Phys. Rev. B, 90, 045137 (2014)