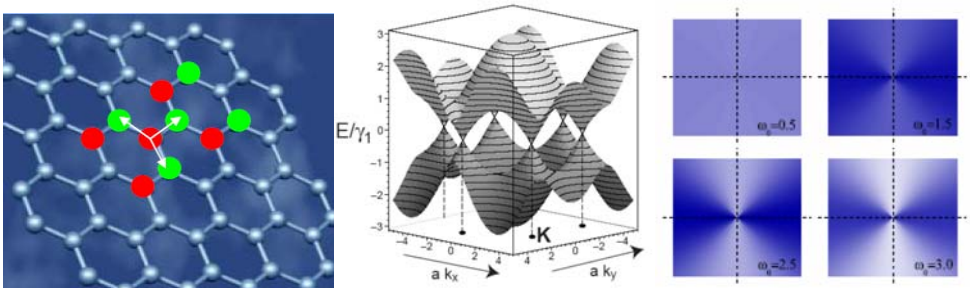
1. Optical properties and quantum transport in graphene and carbon nanotubes: Graphene is two-dimensional carbon atoms localized on a honeycomb lattice. It has the hardest mechanical strength (harder than any known materials, and highest mobility (3 times higher than the best and purest semiconductors). The project is to perform the analysis and modeling of optical response and charge transport in this amazing materials.



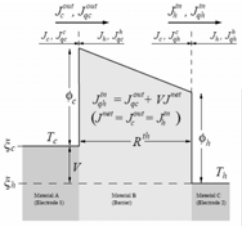
2. Terahertz optoelectronics: terahertz (10^{12} Hz) falls between the electronics and photonics, it overlaps with many fundamental energies in nanomaterials and devices. The project studies linear and nonlinear response of electronic systems under intense terahertz radiation, free carrier absorption, plasmon excitation.

The generation of electromagnetic waves is governed by the Maxwell equations:

$$\nabla \times \vec{H} = \frac{4\pi}{c}\vec{J} + \frac{\partial \vec{D}}{\partial t}$$

Electronics ---→ THz window ←-----Photonics

3. Thermionics in nanomaterials: the project develops new nanometer size structures that have superior thermoelectric performance. Through computer modeling, we will determine the key quantities such as thermal conductivity, electron ballistic transport rate, and figure of merit of the device.



$$ZT = \frac{S^2\sigma}{\kappa}$$

- ❑ *Compact*
- ❑ *Scalable*
- ❑ *Integrable*
- ❑ *Reliable*
- ❑ *Environmentally friendly*
- ❑ *Working in both directions*

4. Dynamics in spintronics systems: The rapid emerging field of spintronics promises to provide new advances that have a substantial impact on future applications. The speed and circuit density of spintronic devices is at least one order of magnitude higher than the current electronic devices. This project will tackle this challenge by solving several problems in dynamical spin and charge transport in semiconductors.