ECE 5390/MSE 5472, Fall Semester 2015
Quantum Transport in Electron Devices & Novel Materials

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Suggested Project Topics

Policy on assignments: Finalize project topics by **Friday, Oct 16th, 2015**.

General notes: The suggested topics are guidelines; the exact topics will be finalized through discussions. You will research the topic, prepare a first short report and presentation by end of October, and a final paper and presentation at the end of the semester. Projects can be done individually, and if done in teams, the roles of each person should be well defined.

Suggested project topics:

1) **Designer transistors from the bottom-up**

   The project will investigate a *bottom-up* transistor design paradigm by identifying the bandstructure of transistor channels and nature of contacts for specific needs: e.g. for high-speed amplification, for oscillators, for high voltage, or low power logic.

2) **Tunneling in the path-integral formulation**

   The project will apply the path-integral formulation to electron tunneling through barriers, identify differences from the conventional WKB, and explore the connection of the path-integral approach to statistical mechanics via imaginary time.

3) **New dimensionality effects on transport devices**

   The project will systematically investigate the effect of dimensionality on diffusive and tunneling transport in devices, and identify new opportunities for designing in features that take advantage of lower dimensions (e.g. dielectric environments).

4) **Acousto-electric coupled transport in light-mass semiconductors**

   The project will investigate the effects of potential strong coupling of electron transport to lattice vibrations in light of the emergence of semiconductors with light atoms (e.g. BN, diamond, etc) for situations when sound velocity and electron velocities become comparable.

5) **Charge density waves and correlated transport**

   The project will investigate the physics of charge-density waves as the ground state of some materials, their transport and stability, and potential applications in electronic devices.

6) **Geometric and topological phases for 'protected' transport**

   The project will investigate the roots of electronic polarization in semiconductor crystals via the Berry phase, and relate it to the physics of quantum-Hall transport. How protected are topological states from scattering and dissipative processes?

7) **Fermions that attract**

   The project will investigate the physics of effective attraction between fermion particles, similar to the Cooper pair in superconductivity. What other mechanisms can pair electrons? If so, what are the consequences on statistics and transport, and potential applications?

8) **Mott insulators and correlation effects**

   This project will investigate many-particle effects such as exchange and Coulomb correlation on the energy and dynamics of electronic systems. Special focus would be the roles played by the dimensionality and energy dispersions of the electron systems.