

## **Nanoscience:** Electron transport in an Aharonov-Bohm (AB) ring with coupled quantum dots (QD)

We study transmission resonances in parallel coupled QD systems, electron spin in coupled QD transport, and coupled QD systems as qubits. Specifically, we investigate:

- the Fano resonant structure of coupled parallel QD's with single and double quasi-bound states,
- measurements of electron decoherence,
- spin-filtering effectiveness of various coupled QD configurations,
- qubit formation and entanglement of states, and
- potential applications of nanorings to quantum information and quantum computing.

The theoretical framework of transmission resonances and phase analysis of AB rings with embedded QD's has specific **applications** as follows:

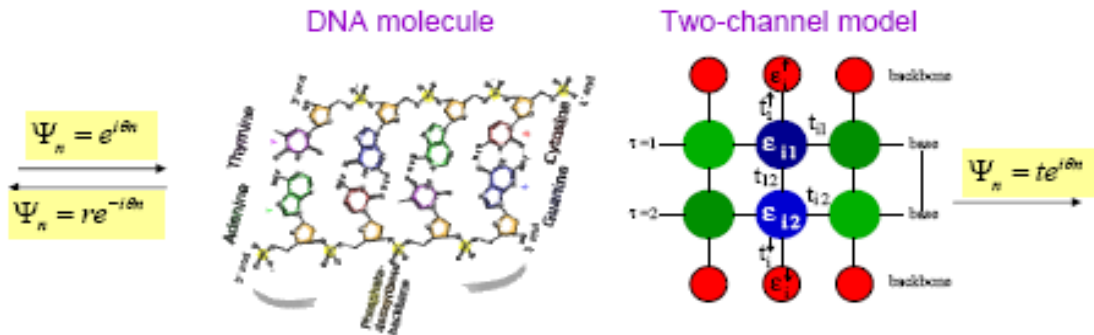
- a) Design of new types of *electronic devices*: interference transistors, sensing devices, and quantum computer implementations.
- b) Prediction of new *techniques of fabrication* in quantum nanodevices for electrical and optical applications.
- c) *Molecular logic gates* composed of cyclic molecular systems coupled to multiple leads in which an external magnetic field can modulate the conductance through the AB effect.

## **Biophysics:** Charge transport through DNA molecules

Electron transport is an important process that controls physical properties and chemical activities of many molecular and biological systems, including DNA. Many applications of nanotechnology, such as biosensors, solar energy, molecular and bioelectronics have greatly benefited from research on various critical electron transport phenomena. For example, charge migration in DNA is directly related to the detection of damage in DNA which may occur in the cells of human beings. DNA damage is responsible for many neurological diseases, and plays an important role in aging and in many forms of human cancer. A better understanding of the properties managing charge migration and its relation to DNA damage may lead to greater insight into damage prevention and repair.

The objectives of our study are to theoretically investigate how DNA molecules support rather high electrical currents given the right environmental condition. Therefore, we develop a simplified model of the DNA double-helix molecular structure in which the effects of base pair sequencing, contact coupling between the DNA and the electrodes, temperature effects, and transport sensitivity to an environmental magnetic field can be varied and studied. We use (a) an effective tight-binding Hamiltonian for a quasi-one-dimensional model of coherent charge transport in DNA and (b) an alternative two-channel ladder model to account for the full double-strand nature of DNA. These studies further our understanding of how charge transport can play a role in determining the

possibility of molecular electronic device applications (DNA-based biosensors and nanobioelectronics) and in detecting DNA damage by mutations.



The two-channel ladder model for electronic transport along DNA.

**Applied Physics:** Radiation characteristics of a parallel-plate waveguide in the presence of a receiving waveguide antenna

We investigate the radiation characteristics of waveguide antennas located on the same impedance plane are theoretically and experimentally. We calculate the key parameters of antennas, such as the coefficient of standing waves, radiation patterns, and decoupling level between antennas in order to study the influence of surface impedance. Since a decoupling level for a fixed geometry reaches a saturation point when the reactivity of normalized impedance becomes capacitive impedance, we incorporate a corrugated structure on a conducting surface with dielectric materials. The radiation patterns in this system are examined for both an ideal conducting flange and capacitive impedance. We also perform an experiment on the frequency dependence of the decoupling level by preparing a sample decoupling device with constant depths of corrugation, and compare numerical and experimental results.