QPhysics AT QUEENS COLLEGE

Colloquium Notice

Anatoly Smirnov

RIKEN, Japan, and The University of Michigan, Ann Arbor

Physics of natural nanodevices: proton pumps and rotary biomotors

In the process of respiration a living cell extracts energy from light or from food and converts it to a proton electrochemical gradient across an inner mitochondrial membrane. Mitochondria are small organelles inside the cell, which serve as efficient power plants. On the next stage of the respiration process protons flow back and rotate ATP synthase - a nanomachine using energy of mechanical rotation to synthesize the energy currency of the cell - the ATP molecules. Cytochrome c oxidase (CcO) is an enzyme, which is able to harness energy of food-stuff electrons and pump protons against the transmembrane voltage gradient. Despite the fact that the crystal structure of this enzyme is known in detail, a mechanism of proton pumping is poorly understood. The physical picture of the torque generation and a proton translocation in the rotary biomotor F0 of ATP synthase remains also unclear. In the present talk we apply the methods of quantum transport theory to the above-mentioned bioenergetic problems and develop a simple kinetic model of CcO proton pump. We also propose a theoretical description of the rotary biomotor F0. For realistic parameters the model of the CcO proton pump works with efficiency 95% and reproduces all four experimentally observed kinetic phases of the proton pumping process. The model of the rotary biomotor includes a stator part and a ring-shaped rotor having twelve proton-binding sites. We show that this system can work in three different regimes found in experiments: at low temperatures the loaded motor shuttles protons without producing any unidirectional rotation, whereas at higher temperatures the motor generates a constant torque with efficiency about 80%. Finally, the system works as a proton pump in the presence of a significant external torque produced by ATP hydrolysis.

References:

1. A. Yu. Smirnov, L. G. Mourokh, and F. Nori, Kinetics of proton pumping in cytochrome c oxidase. arXiv:0812.1785 (2008)
2. A. Yu. Smirnov, S. Savel'ev, L. G. Mourokh, and F. Nori, Proton transport and torque generation in rotary biomotors, Phys. Rev. E **78**, 031921 (2008).

Monday
March 23, 2009
Starts at 12:15 PM
Coffee at 12:00 PM
Physics Conference Room, SB B326