Tata Institute of Fundamental Research
Survey No. 36/P, Gopanpally Village, Serilingampally, Ranga Reddy Dist., Hyderabad – 500 046

Seminar

Optimal Control Protocols for the F_1-ATPase Motor

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A biomolecular motor composed of protein complexes exchanges energy, matter, and information with its surroundings. Despite being in contact with a fluctuating environment, it performs (on average) a directed motion in accordance with the second law by transducing chemical energy stored in the surrounding environment. Among several biomolecular motors the F_0F_1-ATP synthase has gained much attention due to its high efficiency. It produces ~95% of the cellular ATP (adenosine triphosphate) from ADP (adenosine diphosphate) and P_i (inorganic phosphate). The membrane-embedded F_0-unit utilises energy from proton flux to rotate the F_1-unit's γ-crankshaft and synthesises ATP molecules. Since the γ-crankshaft rotates as fast as ~350 revolutions per second, it remains a puzzle how F_0F_1 transduces free energy in a highly efficient manner. One possible way to investigate this is to uncover the functional principle of that particular unit where ATP is synthesised, i.e., the F_1-ATPase. To this end, we focus on an isolated F_1-ATPase, which can also be controlled in an experimental setup. We design a control protocol (mimicking F_0 operation) by which the F_1 unit's γ-crankshaft can be rotated to synthesise ATP at low dissipation. We follow a near-equilibrium framework to construct a non-trivial designed protocol. Then, we rotate the crankshaft with this designed protocol to compute dissipation. Our analysis reveals that the designed protocol dissipates less energy than a constant velocity protocol for a wide range of protocol durations.

Tuesday, Aug 13th 2024

16:00 Hrs (Tea / Coffee 15:45 Hrs)

Auditorium, TIFR-H