Announcing the Final Examination of Mr. Swarnadeep Seth for the degree of Doctor of Philosophy in Physics

Date: October 31, 2023

Time: 11:30 a.m.

Room: PSB 160-161

Zoom Link: https://ucf.zoom.us/j/93931771913

Dissertation title: DNA Capture and Translocation through Nanopore

Abstract:

This thesis investigates DNA dynamics and translocation through nanopores using Brownian dynamics (BD) simulations, offering insights into sequencing technologies, DNA marker detection, and accurate barcoding utilizing solid-state nanopore platforms. First, we *in silico* study the intricate process of capture and translocation in a single nanopore. Our simulation reveals a high probability of hairpin loop formation during the capture process. However, attaching a charged tag to one end of DNA improves multi-scan rates and enhances unidirectional translocations. We use modulating voltage biases to multi-scan a λ-phage dsDNA with oligonucleotide flap markers (tags) through a single and double nanopore system. Our study shows that the bulkier tags introduce velocity variations along the chain length that lead to potential inaccuracies in genetic distance (barcode) estimations. We introduce an interpolation scheme that incorporates both the tag velocities and the average velocity of the chain to improve barcode precision. Subsequently, we include bead and side-chain tags to explain asymmetric dwell time distributions as observed in double nanopore experiments. Our findings indicate that local charge interactions between tags and the nanopore's electric field introduce dwell time asymmetries that can be used for discriminating tags based on their net charges. Finally, we obtain the current blockades of the molecular motifs attached to a dsDNA using electrokinetic Brownian dynamics (EKBD) simulation. Our simulation demonstrates that divalent salt reduces the translocation speed, facilitating precise measurement of the motif's dwell time. Finally, we formulate a volumetric ansatz to construct current blockade diagrams from the ordinary BD simulation in a computationally efficient way and show that using simple scale factors, these volumetric blockades can be mapped accurately to the ionic current blockades obtained from more expensive EKBD simulation. Our studies present comprehensive explorations of DNA translocation and barcoding methods in solid-state nanopores, demonstrating their utility in nanopore sequencing and nanobiotechnology.

Outline of Studies:

Major: Physics

Educational Career:

B. S. - M.S. Dual Degree in Physics, Indian Institute of Science Education and Research Kolkata, India, 2018

Committee in Charge:
Dr. Aniket Bhattacharya (Chair)
Dr. Bo Chen
Dr. Ellen Kang
Dr. Andres Campiglia (External Committee Member)

Approved for distribution by Dr. Aniket Bhattacharya, Committee Chair, on October 6, 2023.

The public is welcome to attend.