中央大學物理學系
Department of Physics, National Central University

Colloquium

Revisiting Magnetic Heterostructures - From Deterministic to Stochastic Spintronics Devices

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Abstract :
Magnetic tunnel junctions (MTJs) have been crucial components in the processing and memory blocks of traditional computing systems for the past two decades, relying on stabilized magnetization and resistance. Recently, innovative approaches such as probabilistic bits and neuromorphic computing have emerged as promising solutions for next-generation memory and logic devices aimed at unconventional computing. However, modern computing techniques often require large circuit areas and significant energy for neuromorphic applications. In contrast, stochastic computing presents a compelling alternative to conventional binary computing, offering lower area costs, reduced power consumption, and greater robustness against noise. One of the most promising approaches is spintronics, which leverages the intrinsic stochasticity of MTJs. In this presentation, I will first provide a brief overview of the development of spintronics, tracing its evolution from giant magnetoresistance (GMR) to tunneling magnetoresistance (TMR) in MTJs, and then examine the tunable, intrinsic stochasticity of MTJs and memristors. Finally, I will focus on the unconventional characteristics, particularly the charge stochasticity in MTJs [1], including an investigation of random telegraph noise (RTN) associated with charge fluctuations in these junctions [2-4].

References:

1. Nano Lett. **25**, 11776 (2025); Featured on the Journal Cover. *"Stochastic Nature of Voltage-Controlled Charge Dynamics in AlOx Magnetic Tunnel Junctions"*
2. Sci. Rep. **14**, 13664 (2024); *"Bias polarity dependent low-frequency noise in ultra-thin AlOx-based magnetic tunnel junctions"*
3. Electronics **15**, 2525 (2021); *"Low-Frequency 1-f Noise Characteristics of Ultra-Thin AlOx-Based Resistive Switching Memory Devices with Magneto-Resistive Responses"*
4. Sci. Rep. **11**, 6027 (2021); *"Electrically programmable magnetoresistance in AlOx-based magnetic tunnel junctions"*

Keywords: Stochastic Computing, Random Telegraph Noise (RTN), Magnetic Tunnel Junctions (MTJs), Spintronics