Information Mechanics with Nanoscale

A series of 6 lectures integrating the mechanics of information manipulation to the physics of nanoscale devices. June 23-July 10. Bâtiment 220, Université Paris-Sud.

The lectures are specifically tailored to target researchers and students in both nanoscale physics and electrical engineering. No background in information theory is required.

Sandip Tiwari, Visiting Professor, Université Paris-Sud, and Charles N. Mellowes Professor in Engineeering, Cornell University, USA.

Information is physical. Information processing therefore necessarily intimately ties the mechanics of manipulation to the physics of devices. We traditionally think of devices and their circuits for binary manipulation as components of logic and memory, and of sensing and transmission. Sometimes they are self-imbued with multiple characteristics. In current electronics, a static random access memory (used at the core of processors) is self-sensing, while a dynamic random access memory (used in the periphery of processors) is not. This line of thinking can have significant impact when applied to nanophysics.

In this series of lectures, I will develop unifying ideas from information and statistical mechanics in condensed matter as applied to electronic, magnetic and mechanical devices at nanoscale and ending with advanced thoughts of open questions this all raises.

All lectures will be given room 44 (salle Pierre Grivet) at Institut d'Electronique Fondamentale (Bât. 220). Coffee, juice and cakes will be served at 10:45am.

For any information, please contact Prof. Sandip Tiwari (st222@cornell.edu) and Dr. Damien Querlioz (damien.querlioz@u-psud.fr)

The following is a rough outline I expect to follow.

Tuesday June 23, 11am.

Lecture 1: Mechanics of information

- Information is physical
- Shannon's theorems

- Principle of maximum entropy
- Conservation and non-conservation
- Circuits from infodynamic view

Friday June 26, 11am

Lecture 2: Deterministic information manipulation

- Fluctuations and transitions
- Memories: Bistable and random-walk
- Errors, stability and energy costs

Tuesday June 30, 11am

Lecture 3: Nanoscale transistors

- Geometries and scaling
- ``Off-state'' and ``On-state''
- Nanoscale conduction
- Scale connections

Friday Jul 3, 11am

Lecture 4: Phase transition in devices

- Symmetry breaking
- Mean-field approach
- Ferroelectric memories
- Electron correlations
- Spin correlations

Tuesday Jul 7, 11am

Lecture 5: Mechanics and its nonlinearities

- Coupled mode analysis
- Consequences of nonlinearity
- Continuum to nanoscale

Friday Jul 10, 11am

Lecture 6: Gestalt

- Review of integrative thoughts
- Example of open questions relevant to information mechanics
    - Energy-related
    - Complexity-related
    - Specific to nanoscale
    - Specific to information question posed

About Prof. Sandip Tiwari:

Sandip Tiwari, a native of India, was educated starting in Physics before moving to Electrical Engineering, attending IIT Kanpur , RPI, and Cornell, and after working at IBM Research, joined Cornell in 1999. He has been a visiting faculty at Michigan, Columbia, Harvard, IISc, Stanford and TUM, the founding editor-in-chief of Transactions on Nanotechnology and authored a popular text book of device physics. He is currently the Charles N. Mellowes Professor in Engineering. His research has spanned the engineering and science of semiconductor electronics and optics, and has been honored with the Cledo Brunetti Award of the Institution of Electronic and Electrical Engineers (IEEE), the Distinguished Alumnus Award from IIT Kanpur, the Young Scientist Award from Institute of Physics, and the Fellowships of American Physical Society and IEEE. Particular joyful to him is discovering scientific explanations, uncovering new phenomena, inventing new devices and technologies, and moving in directions that are of broader societal use. Through National Nanotechnology Infrastructure Network (NNIN) and in his personal life, he is also active in bringing broader education, openness and understanding and cooperation across this world.