Distinguished Lecture *by*

Professor Steven Chu

Entropy, Molecular Motors, and Non-thermal Equilibrium Statistical Physics

April 3, 2023 (Mon)

2:30 pm (HKT)

Room G07,
Main Building,
HKU Main Campus

SPEAKER

Professor Steven Chu

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- Former US Secretary of Energy
- Nobel Laureate in Physics 1997

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ABSTRACT

The transport of molecular cargos in neuronal cells is analysed in the context of new developments in statistical physics. Our development of very bright optical probes enabled the long-term single tracking of molecular cargos in live neurons for tens of minutes. The number of dynein motors transporting a cargo was found to switch stochastically from one to up to five motors during the long-range transport in neurons. We are able to resolve individual molecular steps, and formulated a new, quantitative chemo-mechanical model where two ATP molecules are hydrolysed sequentially. Our model is consistent with extensive structural, single-molecule and biochemical measurements.

The observed fluctuations in movement can be described by a steady-state non-thermal equilibrium effective temperature. The Fluctuation Theorem, first proved in 1993 and applicable in any non-thermal equilibrium processes, is shown to yield a minimum “uncertainty principle” limit, where the product of heat entropy and the statistical precision of any physical operation is greater than or equal to $2k_BT$. In the context of intercellular molecular transport, we show that a smaller variance in the movement of the cargo vesicle demands a greater expenditure of energy.

BIOGRAPHY

Professor Steven Chu is currently the William R Kenan Jr Professor of Physics, and Professor of Molecular and Cellular Physiology, and of Energy Science and Engineering at Stanford University. He holds a BA in mathematics and a BSc in physics from the University of Rochester, and a PhD in physics from the University of California, Berkeley.

He received the 1997 Nobel Prize in Physics for laser cooling and trapping of atoms together with Claude Cohen-Tannoudji and William Daniel Phillips. Other contributions included the first optical tweezers manipulation of biomolecules, precision atom interferometry based on optical pulses of light, and single molecule FRET of biomolecules tethered to surfaces. He has continued developing and applying new methods in molecular biology and medical imaging, materials science, and batteries.

Throughout his career, Professor Chu has sought new solutions to the world’s energy and climate challenges. He served as US Secretary of Energy from 2009 to 2013 – the first Nobel Laureate to be appointed to the US Cabinet, and the second Chinese American – and pursued an ambitious agenda to increase investment in clean energy, reduce dependence on fossil fuels, and address the global climate crisis.

Professor Chu has served as President of the American Association for the Advancement of Science, a Senior Advisor to the Directors of the National Institutes of Health and the National Nuclear Security Agency. He holds 35 honorary degrees, and is a member of the US National Academy of Sciences and many international academies, including *inter alia*, the Royal Academy of Engineering, the Academia Sinica, the Korean Academy of Sciences and Technology, the Chinese Academy of Sciences and the Pontifical Academy of Sciences at the Vatican.