DAVID M. LEE HISTORICAL LECTURE IN PHYSICS 2023

STEVEN CHU

William R. Kenan Jr. Professor of Physics
Professor of Molecular and Cellular Physiology and of Energy Science and Engineering

Stanford University

1997 Nobel Laureate

Colloquium

"Entropy, molecular motors, and non-thermal equilibrium statistical physics"

Monday, April 24, 4:30 p.m.

The transport of molecular cargos in neuronal cells is analyzed in the context of new developments in entropy and statistical physics. Our development of very bright optical probes enabled the long-term single tracking of molecular cargos in live neurons. The number of active dynein motors transporting a cargo is found to switch stochastically from one to five dynein motors during the long-range transport in neurons. Our probes allowed the observation of individual molecular steps where the time between single steps is controlled by two temperature-dependent rate constants. This finding suggests that two ATP molecules are hydrolyzed sequentially during each dynein step.

The measured fluctuations can be described by a steady-state non-thermal equilibrium temperature, T_{eff} as high as $30 \times T_{cell} = 30 \times 310\ K$, and inversely proportional to the number of motors. Using the Fluctuation Theorem (proven in 1993) is consistent an "uncertainty principle" limit, $\Delta Q \cdot \epsilon^2 \geq 2k_B T_{eff}$, where $\Delta Q = T_{eff} \Delta S$ is the *minimum* heat entropy needed to achieve an outcome with a given statistical precision. This theorem sets a lower limit to the heat energy needed to achieve a given precision in any physical operation. In the context of intercellular molecular transport, a smaller variance in the displacement of the vesicle demands a greater expenditure of energy.

Lee Historical Lecture in Physics

"A random walk into laser cooling, optical trapping and beyond"

Tuesday, April 25, 5:00pm

A personal perspective of how laser cooling and optical trapping of atoms and biomolecules was developed. Emphasis will be given on how an elementary understanding of the physics at an undergraduate physics level led to success in initial successes. Once the basic tools of optical molasses and optical trapping were developed, more random walks into polymer physics and biology will be described.

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17 Oxford Street, Lecture Hall Jefferson 250, Cambridge, MA
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HARVARD UNIVERSITY
Department of Physics

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