

New Theorems in Non-Equilibrium Thermodynamics

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-12.15pm-

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-Abstract-

Thermodynamics is the study of the flow of heat between states and its transformation into work. Our understanding of thermodynamics is largely confined to equilibrium states. The field of “nonequilibrium thermodynamics” represents a simple-minded extension of the 19th century concepts of equilibrium thermodynamics to systems that are close to, or near equilibrium.

Moreover, these traditional concepts are limited in application to large systems, referred to as the “thermodynamic limit”.

However, in the last decade, two new theorems have been proposed to revolutionise the field of thermodynamics and its application to modern systems. These new theorems firstly, lift the restriction of the thermodynamic limit, allowing thermodynamic concepts to be applied to small systems, and secondly, characterise systems that may be far-from-equilibrium. The first of these theorems, the Fluctuation Theorem (FT), generalises the Second Law of Thermodynamics so that it applies to small systems, including those that evolve far from equilibrium. The second, the Crooks’ Relation (or equivalently, when cast in ensemble averages, the Jarzynski Equality), provides a method of predicting equilibrium free energy differences from the experimental trajectories of systems.

In principle, these include trajectories that traverse far-from-equilibrium states. Both of these theorems are at odds with a traditional understanding of 19th century thermodynamics where equilibrium is central and the Second Law inviolate. However these theorems are critical to the application of thermodynamic concepts to systems of interest to scientists and engineers in the 21st century.

Both theorems, embody concepts that are not fully explored and are not necessarily accepted amongst scientists; consequently, the practical theorems are not yet widely used. In this talk we will describe the theorems in practitioners’ language, along with our optical tweezers experiments that irrefutably demonstrate the theorems.

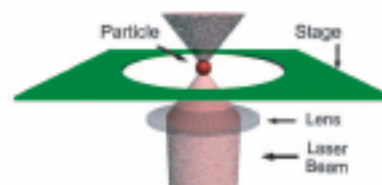


Figure 1: Schematic showing the operating principles of the Optical Tweezers (OT) Apparatus that is used to demonstrate theorems with a colloidal particle. A laser focused through an objective lens of a microscope optically traps a single latex particle. Using a high numerical aperture objective lens, the optically-trapped particle is confined to the focal plane and fluctuates about the focal point.

Venues

- Rankine Brown 106, Victoria University of Wellington-
- Video Conference Room, C-Block, IRL, Gracefield Site, Lower Hutt-
- Level-3 lecture theatre (A309), ELEC Dept Building, Canterbury University-
- ScB2.09 (College of Sciences Board Room), Science Tower B. Massey University-
- Conference Room 2, Otago University-