MPIDS Colloquium

MAX-PLANCK-GESELLSCHAFT

The stochastic thermodynamics of computation

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One of the major resource requirements of computers — ranging from biological cells to human brains to high-performance digital computers — is the energy used to run them. Those energy requirements of performing a computation have been a long-standing focus of research in statistical physics, going back (at least) to the early work of Landauer and colleagues.

However, one of the most prominent aspects of computers is that they are inherently non-equilibrium systems. They are also often quite small, far from the thermodynamic limit. Unfortunately, the research by Landauer and co-workers was grounded in the statistical physics of the 20th century, which could not properly address the thermodynamics of non-equilibrium, nanoscale systems.

Fortunately, recent revolutionary breakthroughs in stochastic thermodynamics have overcome the limitations of 20th century statistical physics. We can now analyze arbitrarily off-equilibrium systems, of arbitrary size. Here I show how to apply these recent breakthroughs to analyze the thermodynamics of computation. Specifically, I present formulas for the thermodynamic costs of implementing (loop-free) digital circuits, of implementing Turing machines, of implementing Bayes nets, and of implementing multipartite processes like the interacting organelles in a cell.

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MPIDS, video conference at www.zoom.us
Meeting ID: 959 2774 3389
Passcode: 651129, direct link

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