COVER IMAGE
Maxwell's demon

ARTWORK BY AILISH SULLIVAN, 2013

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Topics in non-equilibrium physics

As systems and devices become ever smaller, we're increasingly being forced to reconsider ideas we've relied on for decades. Unsurprisingly, this can be quite an undertaking — and none more so, perhaps, than the task of questioning our understanding of thermodynamics. But the notion that the entropy of a system never decreases relies on adequate statistics, and the fact that most systems comprise 10^{23} degrees of freedom. In smaller systems, standard equilibrium physics is no longer sufficient: statistical fluctuations become significant and recent advances have shown that these fluctuations satisfy their own laws.

Much of the current interest in non-equilibrium physics stems from progress in fields as far flung as biology: reconciling the details of biomolecular processes calls into question the thermodynamics of small systems. And the fact that a living system in equilibrium is oxymoronic (or dead) has necessitated the development of new frameworks for understanding otherwise familiar physics. Indeed, as Mark Buchanan points out in this month's Thesis, non-equilibrium physics is even making waves among scientists working on self-replication.

Recently, the development of quantum engines and devices has also motivated our efforts to better understand the behaviour of systems removed from equilibrium. But the art of pushing and prodding at the lore of thermodynamics is as old as James Clerk Maxwell himself, whose demonic thought experiment has long been a source of inspiration (as it was for the image on the cover of this Insight). Renewed interest in Maxwell's ideas, as well as those of Leó Szilárd, has sparked recent theoretical advances, and attempts to realize them experimentally.

We have compiled this Insight to bring these different advances together — a task adeptly described by Christopher Jarzynski in his Commentary on page 105. Neither the collection of topics chosen, nor the articles themselves, are intended to be exhaustive. But in its diversity we find something worth championing — the idea that these complex and elegant ideas might touch on research fields so disparate, and the notion that those fields might feed back to our formal understanding of processes occurring far from equilibrium.

Abigail Klopper, Senior Editor

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