Keeping Time on Entropy's Dime

An experiment with a nanoscale clock verifies that a clock's entropy per tick increases as the clock is made more precise.

By **Michael Schirber**

Entropy generally increases with each tick of time, so it is natural that a timekeeping device produces an uptick in entropy as it runs. Building on previous work with quantum clocks, researchers now show that a simple classical clock—whose ticks are the vibrations of a heat-driven, nanometer-thick membrane—generates more entropy as its precision is increased [**1**]. The experiments open a new line for exploring how nanomachines can convert random inputs into useful work.

A clock is a machine, and like all machines, it obeys the laws of thermodynamics. Previous studies have looked at quantum clocks, finding a linear relation between their accuracy and the entropy they produce (see **Viewpoint: The Thermodynamic Cost of Measuring Time**). But whether this relation holds for classical clocks is uncertain, as tracking the energy in and out of these larger devices is harder.

Natalia Ares from the University of Oxford, UK, and colleagues designed a classical clock, with tunable precision, for which they could measure energy flows. Their system consisted of a silicon nitride membrane suspended over metal electrodes, forming a tiny cavity.

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The researchers applied a noisy signal to the electrodes, causing the membrane to vibrate at a resonant frequency. A circuit connected to the cavity measured the membrane vibrations and registered a "tick" for each vibration cycle. By raising the energy, or "heat," in the input signal, the team were able to increase the amplitude of vibrations and, in turn, improve the precision of the membrane measurements. They found that the entropy cost—estimated by measuring the heat lost in the probe circuit—increased linearly with the precision, in agreement with quantum clock behavior.

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REFERENCES

1. A. N. Pearson *et al.*, "Measuring the thermodynamic cost of timekeeping," **Phys. Rev. X 11, 021029 (2021).**