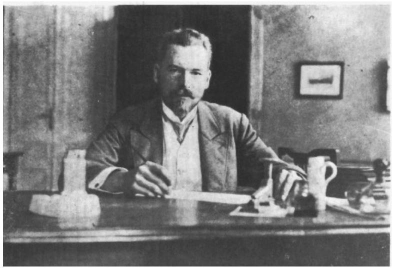

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Fast is hot: energetics of information erasure and the overhead to Landauer's bound

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Information processing in the physical world comes with an energetic cost: Landauer's principle states that erasing a 1-bit memory requires at least $k_B T_0 \ln 2$ of energy, with $k_B T_0$ the thermal energy of the surrounding bath. Practical erasures implementations require an overhead to the Landauer's bound, observed to scale as $k_B T_0 B/\tau$, with τ the protocol duration and B close to the system relaxation time. Most experiments use overdamped systems, for which minimizing the overhead means minimizing the dissipation. Underdamped systems, never harnessed before, thus sounds appealing to reduce this energetic cost.

We use as one-bit memory an underdamped micro-mechanical oscillator confined in a double-well potential created by a feedback loop. The potential barrier is precisely tunable in the few $k_B T_0$ range. We measure, within the stochastic thermodynamic framework, the work and the heat of the erasure protocol. We demonstrate experimentally and theoretically that, in this underdamped system, the Landauer's bound is reached within a 1% uncertainty, with protocols as short as 100 ms.

Furthermore, we show that for such underdamped systems, fast erasures induce a heating of the memory: the work influx is not instantaneously compensated by the inefficient heat transfert to the thermostat. This temperature rise results in a kinetic energy contribution superseding the viscous dissipation term. Our model covering all damping regimes paves the way to new optimisation strategies in information processing, based on the thorough understanding of the energy exchanges. We are indeed able to quantify the overhead to the Landauer's bound with its dependence on the system and protocol parameters, and we identify the physical origins of this energy cost.

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