

Thermodynamics of Information

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1. A bit of history: Maxwell's demon, Szilárd's engine, Bennett's solution.
2. Basic concepts of information theory: Shannon information, mutual information, relative entropy.
3. Basic concepts of stochastic thermodynamics: heat, work, non-equilibrium free energy, master equations, and fluctuation theorems.
4. Information and the second law.
5. Fluctuation theorems for feedback systems.
6. Feedback reversibility and optimal Maxwell demons.
7. Thermodynamic cost of measurement.
8. Information flows.
9. Creating information: symmetry breaking.
10. Maxwell demons in the phase space and microcanonical Szilard engines.

Basic reading

1. J.M.R. Parrondo, J.M. Horowitz and T. Sagawa. Thermodynamics of information. *Nature Physics* **11**, 131-139 (2015).
2. J.M.R. Parrondo, J. Tabanera-Bravo, F. Fedele, and N. Ares Information flows in nanomachines. <https://doi.org/10.48550/arXiv.2312.02068>
3. J.M.R. Parrondo. Thermodynamics of Information. To appear in the Encyclopedia of Condensed Matter Physics - 2nd Edition (edited by T. Chakraborty). <https://doi.org/10.48550/arXiv.2306.12447>

Further reading

Maxwell demons and Szilard engines

4. H.S. Leff and A.F. Rex. *Maxwell's demon 2: Entropy, classical and quantum Information, Computing* (Institute of Physics, 2003).

Information theory

5. T.M. Cover and J.A. Thomas. *Elements of Information Theory* (Wiley, 2005).

Thermodynamic cost of measurement

6. T. Sagawa and M. Ueda. Minimal Energy Cost for Thermodynamic Information Processing: Measurement and Information Erasure. *Physical Review Letters* **102**, 250602 (2009).

Fluctuation theorems and optimal Maxwell demons

7. J.M. Horowitz and S. Vaikuntanathan. Non-equilibrium detailed fluctuation theorem for repeated discrete feedback. *Physical Review E* **82**, 061120 (2010)
8. J.M. Horowitz and J.M.R. Parrondo. Optimizing non-ergodic feedback engines. *Acta Physica Polonica B* **44**, 803-814 (2013).

Information flows

9. J.M. Horowitz and M. Esposito. Thermodynamics with Continuous Information Flow. *Physical Review X* **4**, 031015 (2014).

Creating information

10. J.M.R. Parrondo. The Szilard engine revisited: Entropy, macroscopic randomness, and symmetry breaking phase transitions. *Chaos* **11** 725-733 (2001).
11. É. Roldán, I.A. Martínez, J.M.R. Parrondo and D. Petrov. Universal features in the energetics of symmetry breaking. *Nature Physics* **10** 457-461 (2014).

Maxwell demons in the phase space

12. J.M.R. Parrondo and L. Granger. Maxwell demons in phase space. *European Physical Journal-Special Topics* **224**, 865-875 (2015).