Handout on Norton's "Waiting for Landauer" - Javier Anta

April 9th 2020 - Graduate Course "TD & SM" (HPS 2559) University of Pittsburgh

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Landauer's speculation (1961)

> There is an unavoidable thermodynamic entropy cost of $k \ln 2$ into the environment when 1 bit of information is erased

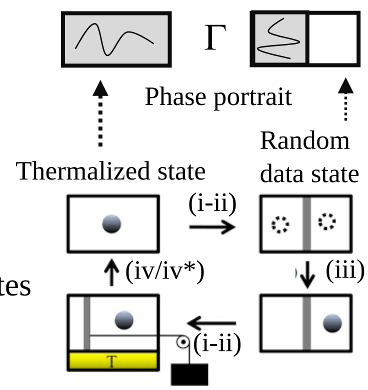
↓ Was promoted to the foundational thesis of the thermodynamics of computation (TC) (Bennet 1982)

(Generalized formulation)

Landauer's Principle

> Logical irreversible computation entails energy dissipation

Dynamically accessible phase volumes



↓ Shizume (1995) Piechocinska (2000)

Direct Proofs — Based on →

(A) Erasure must compress phase space

(B) Random data state entails TD entropy

Norton (2005) Incorrect Assumptions

(A) Erasure only relocate phase space

(B) Random data states and thermalized states are not thermodynamically equivalent

↓ Ladyman et al. (2007, 2008)

Indirect Proofs (LPSG) — Based on →

(C) Statistical form of the Second Law of TD

(D) Not-detailed erasure process (Generality)

(E) Inventory of processes

(i) Reversible isothermal expansion / compression

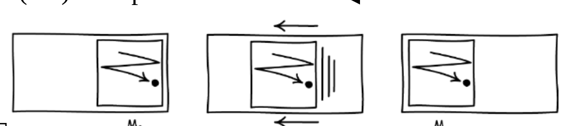
(ii) Removal / insertion of the partition

(iii) Detection / detection and trigger

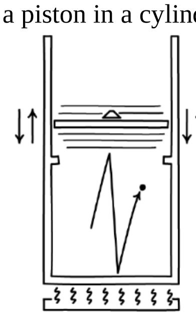
(iv) Shift

Add

(iv*) Dissipationless erasure



One-molecule gas under a piston in a cylinder



Norton (2011)

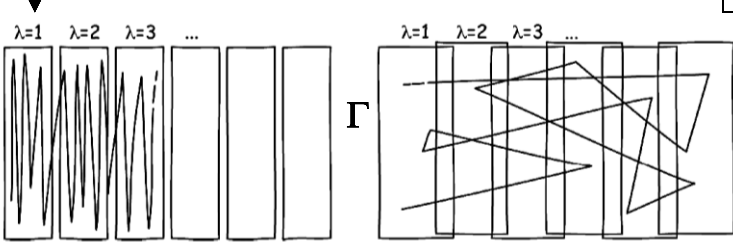
Argued that composite processes from (E) can violate (C)

(i) (ii) (iii) (iv*)

- Neglect of fluctuations
- Reversible isothermal expansion/compression ←
- General result: **No-Go Theorem**

> Fluctuations disrupt all reversible isothermal processes at molecular scales

↓ Phase portrait



(Intended) Probability gradient

(Actual) Equiprobable stages

➡ It is required to generate a probability gradient by an amount of (3) k superior to 'Landauer's limit' (0.69) to proceed from one stage λ to the next one $\lambda + 1$