Mini-lecture

Entropy and the II law: why do we need them?

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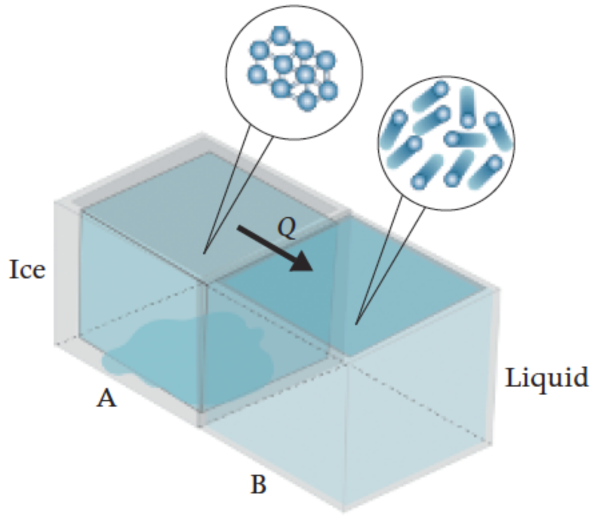
SYMPOSIUM
Teaching and Learning Thermodynamics in a Time of Change

Science Center, Delft University of Technology - July 5th, 2019



TU Delft

Propulsion & Power

The concept of entropy

- II law of thermodynamics → great (!) principle of science
- Based on entropy, a property of matter (analogy with energy and the I law)
- Physical approach: measure of the degree of *microscopic* randomization, disorder and unpredictability

Microscopic view, physical understanding

⇓

Macroscopic hypothesis can be verified

⇓

Entropy balance, engineering

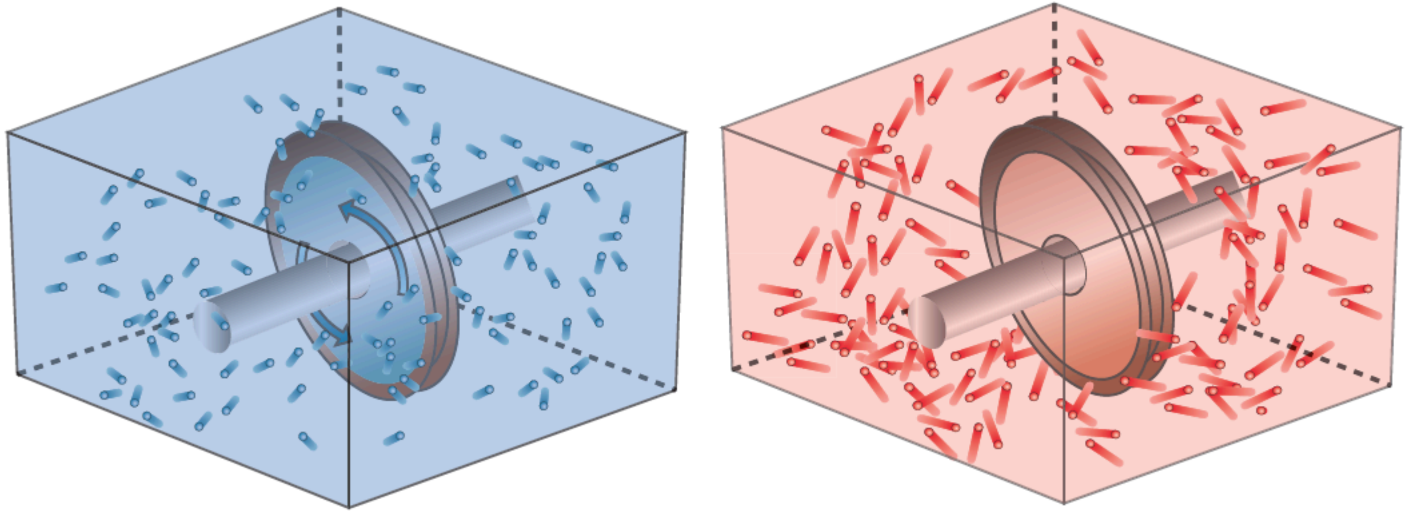
More on entropy…

- Ideas are the basis for a *macroscopic* hypothesis (*entropy hypothesis*) about **entropy as a property of matter**
- Framework provides ways to evaluate entropy of substances (thermodynamic property) → entropy balance
- Equations to predict what can happen and best performance!

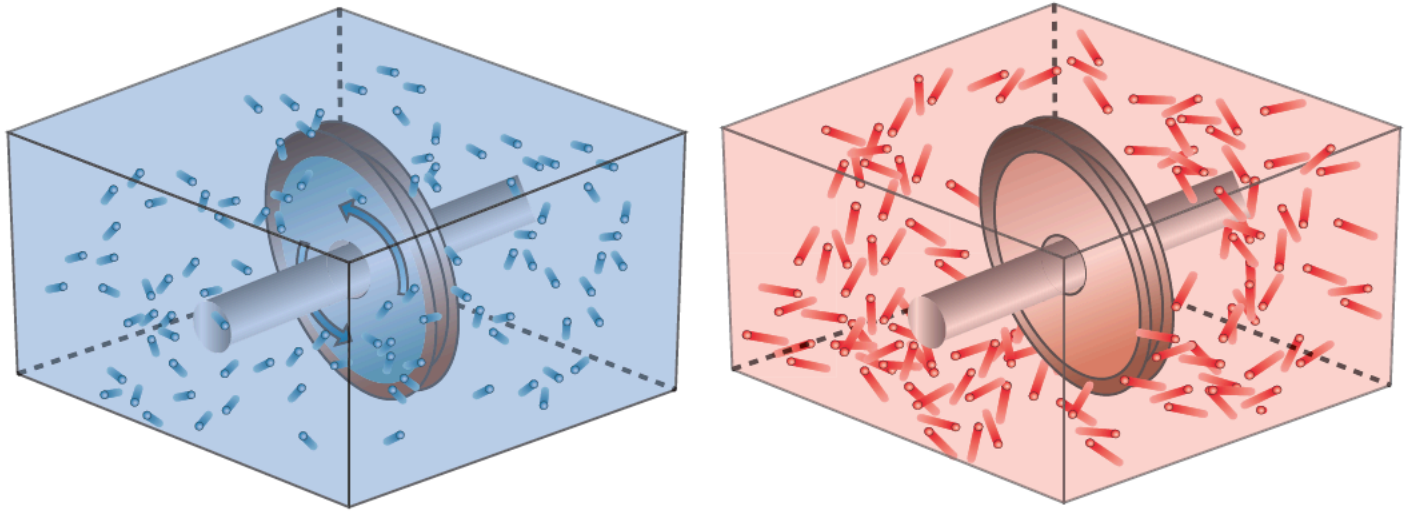
Energy balance: insensitive to time evolution - 1

- Energy balance independent of direction of time

- Example: consider flywheel immersed in gas



(a) State 1: spinning flywheel, cool. (b) State 2: flywheel at rest, warm.



(a) State 1: spinning flywheel, cool. (b) State 2: flywheel at rest, warm.

- Isolated system, energy balance, between time 1 and 2

$$\underbrace{0}_{\text{energy input}} = \underbrace{0}_{\text{energy output}} + \underbrace{E_2 - E_1}_{\text{energy accumulation}} \; ; \; E = U + E_K \quad \Rightarrow \quad U_1 + E_{K,1} = U_2$$

- (1) energy in organized motion of flywheel
- (2) energy in random molecular motion (U_2) due to friction

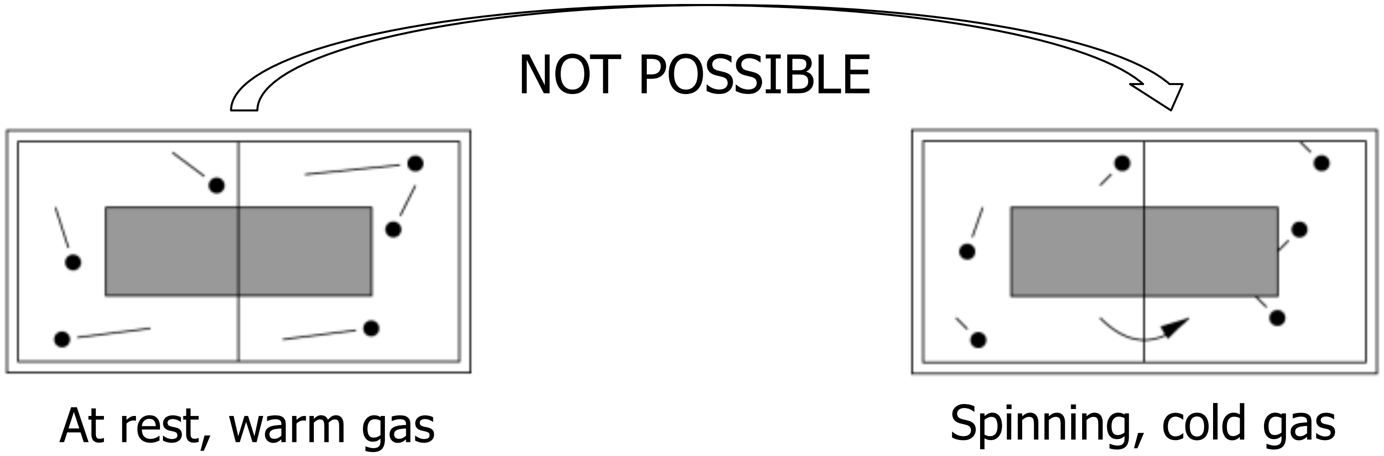
Energy balance and violation of physical evidence

- Invert state 1 and 2: start from 2 (warm, at rest) and end up in 1 (cold, spinning)

$$U_2 = U_1 + E_{K,1}$$

- Energy balance is satisfied !!!
- The process 2→1 cannot happen in reality
- If microscopic disorder, the system cannot microscopically organize itself!
- therefore…

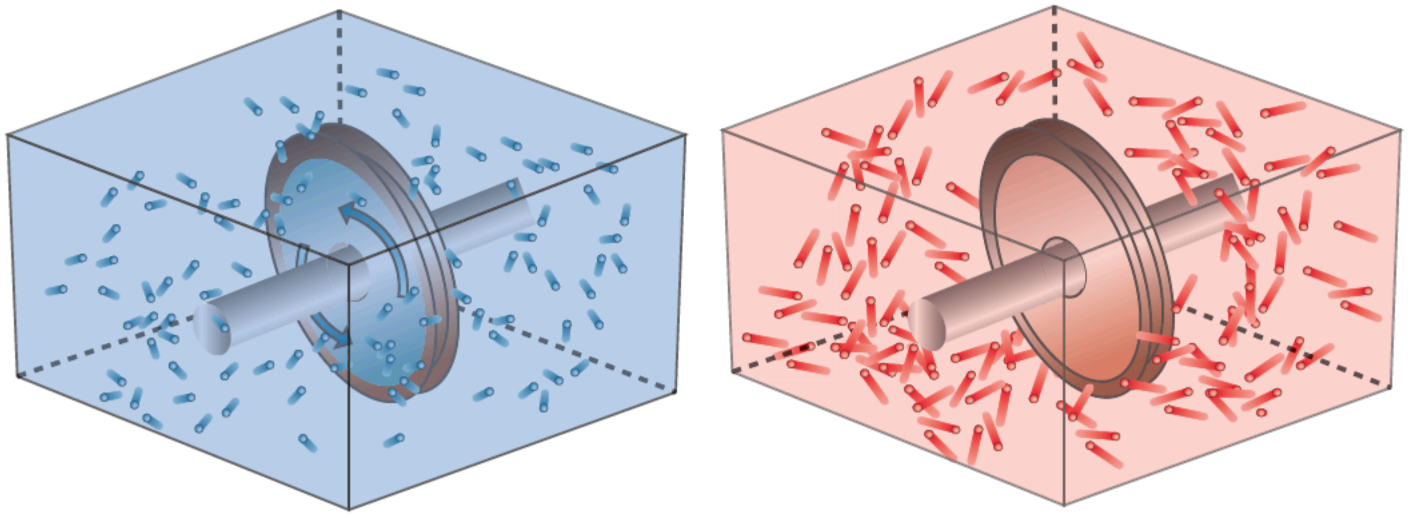
Another principle is needed!



We need another principle in order to perform correct thermodynamic analysis

→ ENTROPY AND THE II LAW

Microscopic view of entropy



(a) State 1: spinning flywheel, cool. (b) State 2: flywheel at rest, warm.

Microscopic randomness: entropy to quantify it.

- State 1: low entropy (organized rotation of the flywheel)
- State 2: high entropy (random motion of warm gas)

$$S_2 > S_1$$

real life analogue: two libraries…

which one is more useful?