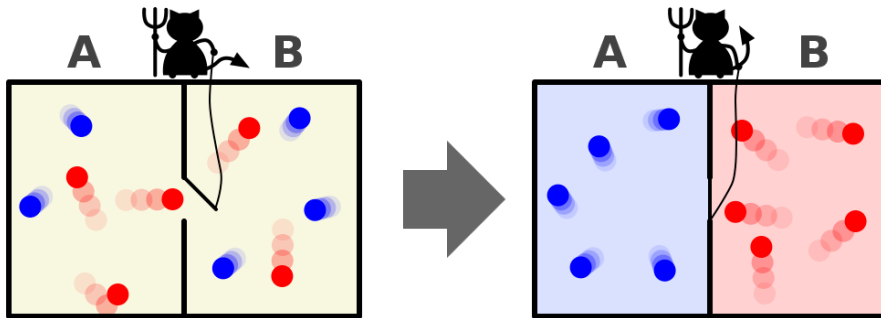# The Brownian Ratchet: A Historical Thought Experiment reproduced at Human-Scale.

A. Meynard, M. Lagoin, C. Crauste-Thibierge, A. Naert.
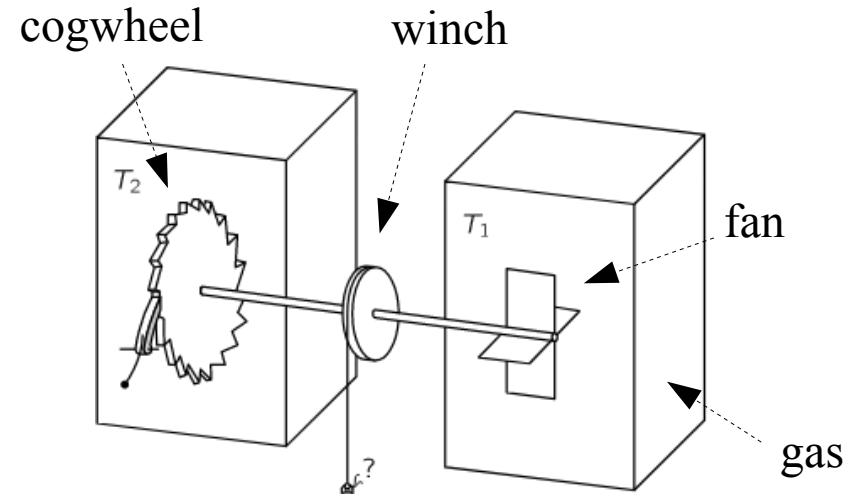Ens de Lyon, CNRS, Laboratoire de physique, France

The Maxwell's demon (1872):

A thought experiment → **paradox**

Feynman's ratchet and pawl:

cogwheel   winch

fan

gas

→ Extract work out of heat, at no cost ?

The Feynman Lectures on Physics, Vol. 1, (1963)

Paradox solved by – Smoluchowski (1912) / Feynman (1962) thanks to an argument based on *thermodynamics*,
and by – Szilard (1929) / Brillouin (1950), introducing *"information"*

→   various developments ant discussions / arguments since then,
on what is information, and its relation with energy, and entropy...
where/when is actually entropy produced?

Thought experiment → <u>macroscopic</u> 'real experiment'

micro-motor as sensor/actuator
→ **unique probe** → global measurement

5cm

2cm x 2cm steel blade
→ **1D Brownian rotor**

3 mm stainless-
steel beads
→ **atoms**
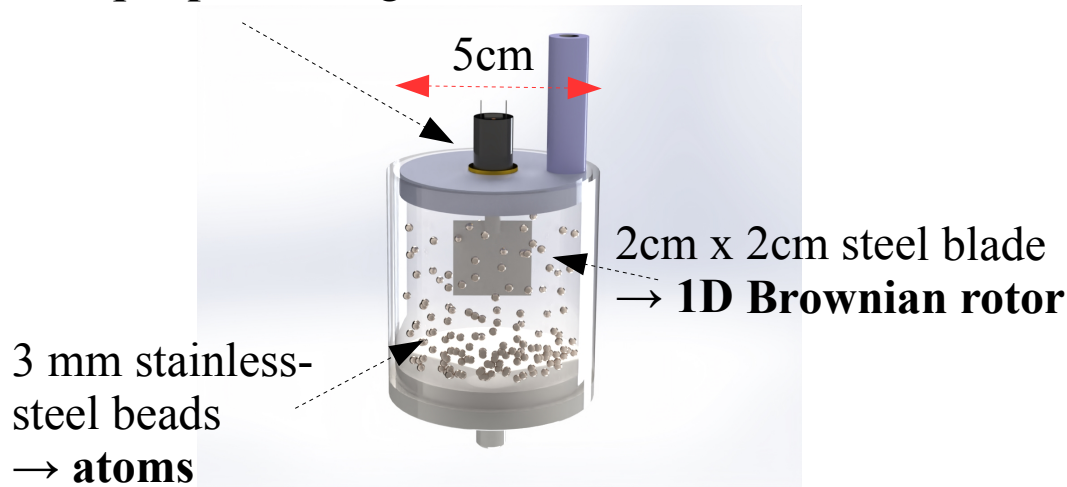
Steadily shaking the beads at a few g
to compensate dissipation → NESS heat bath
(keeps $kT_{eff.}$ = cst).

cogwheel   winch

T_2 T_1

fan

gas
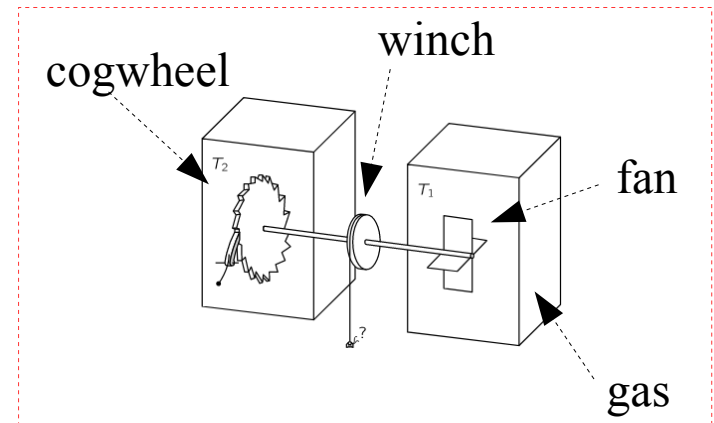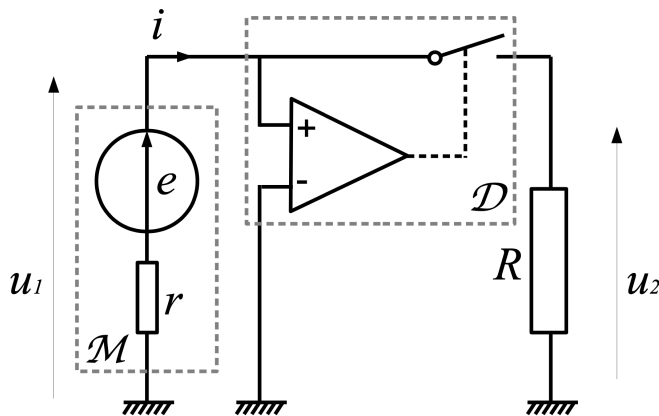
Electro-mechanical conversion:

$$
\begin{cases}
i = \dfrac{u_2}{R} = \dfrac{\Gamma}{\alpha} \quad (motor) \\[2mm]
e = u_1 + ri = \alpha\dot{\theta} \quad (dynamo)
\end{cases}
$$

Here, R represents the load

Much more convenient to handle! (all frictions
can be taken into account)

Allows to measure separately: – heat, work, efficiency,
– information measurement/erasure.

Thank you for listening,
    Please come and see my poster!

i

$+$

$-$

$\mathcal{D}$

e

u_1

r

$\mathcal{M}$

R

u_2