MATH327: Statistical Physics

Tuesday, 30 January 2024

902 907

1905 Einstein

1908 Perrin → 1926 Nobel

Something to consider

The existence of atoms was established long before technology could identify individual atoms.

What sort of debates might this have involved?

[Could similar debates be relevant to string theory?]

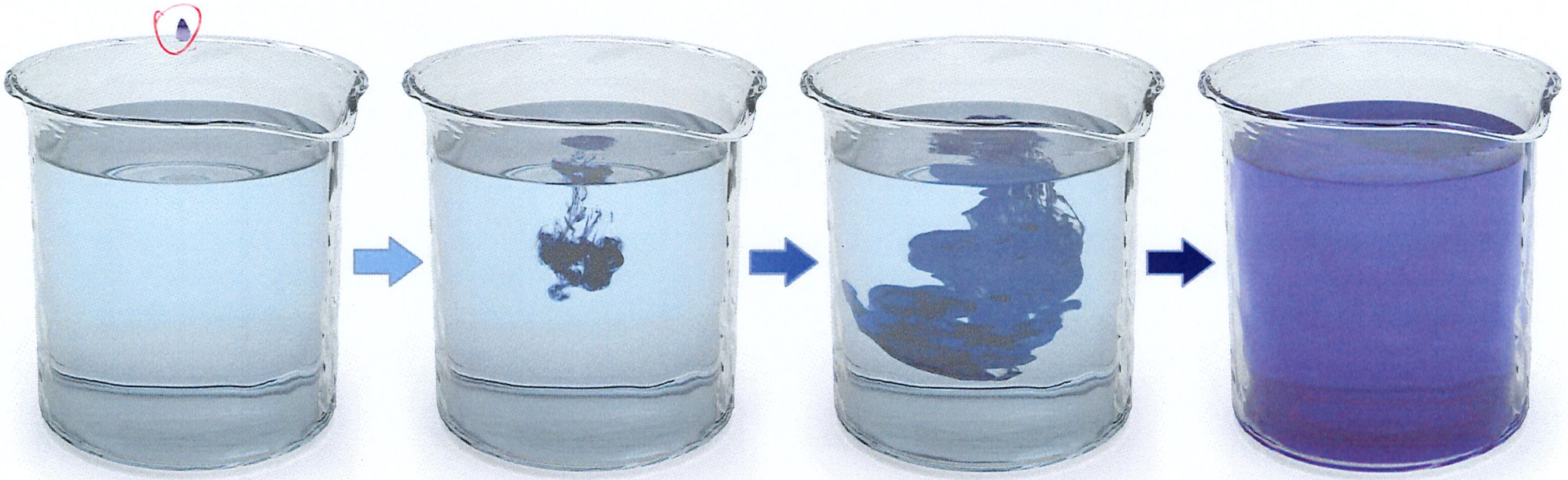
Plan

Big picture

Logistics

Probability foundations

"Arrow of time"



commons.wikimedia.org/wiki/File:Blausen_0315_Diffusion.png

THE NOBEL PRIZE IN PHYSICS 2021

Illustrations: Niklas Elmehed

Syukuro Manabe

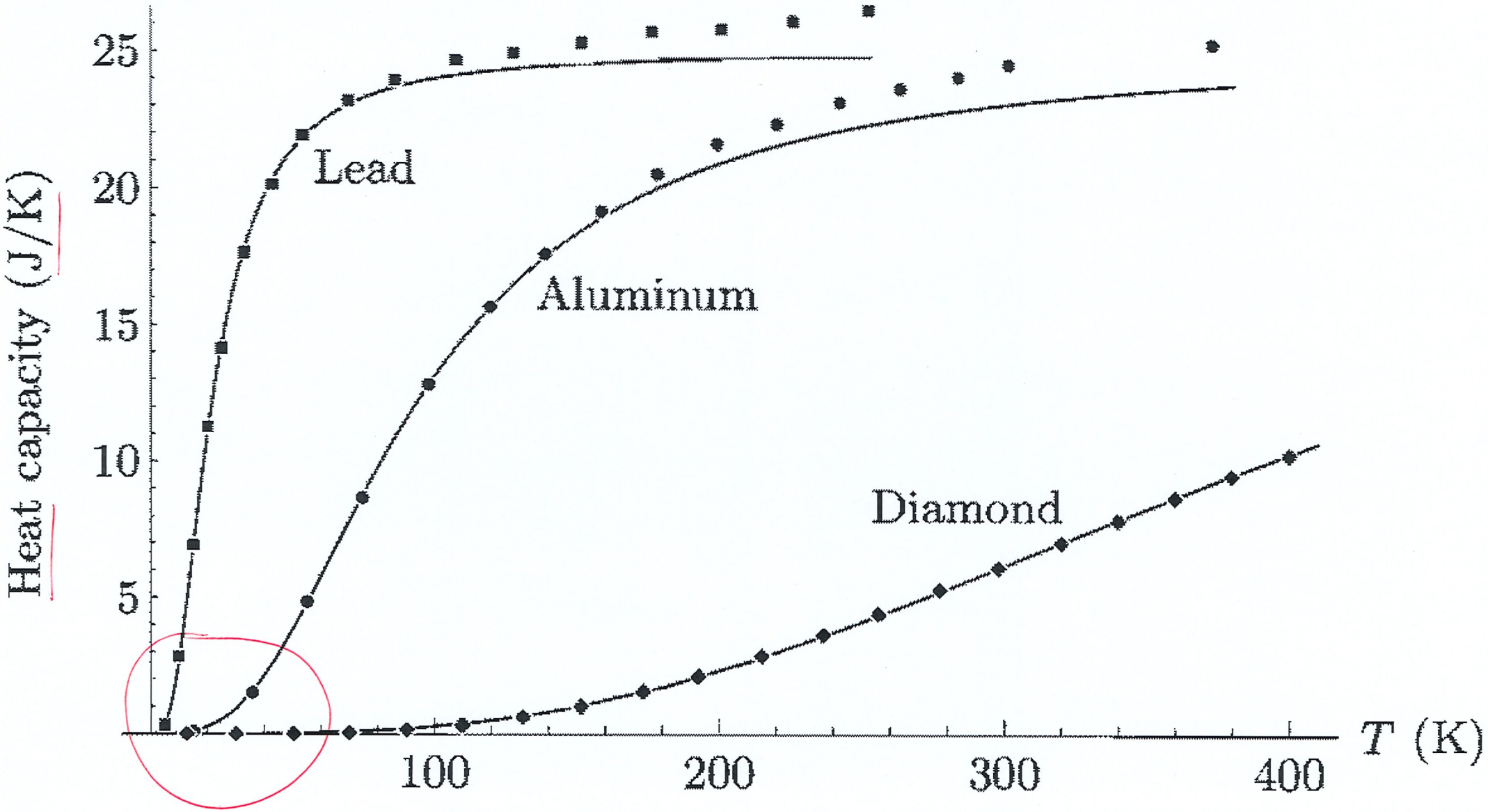
Klaus Hasselmann

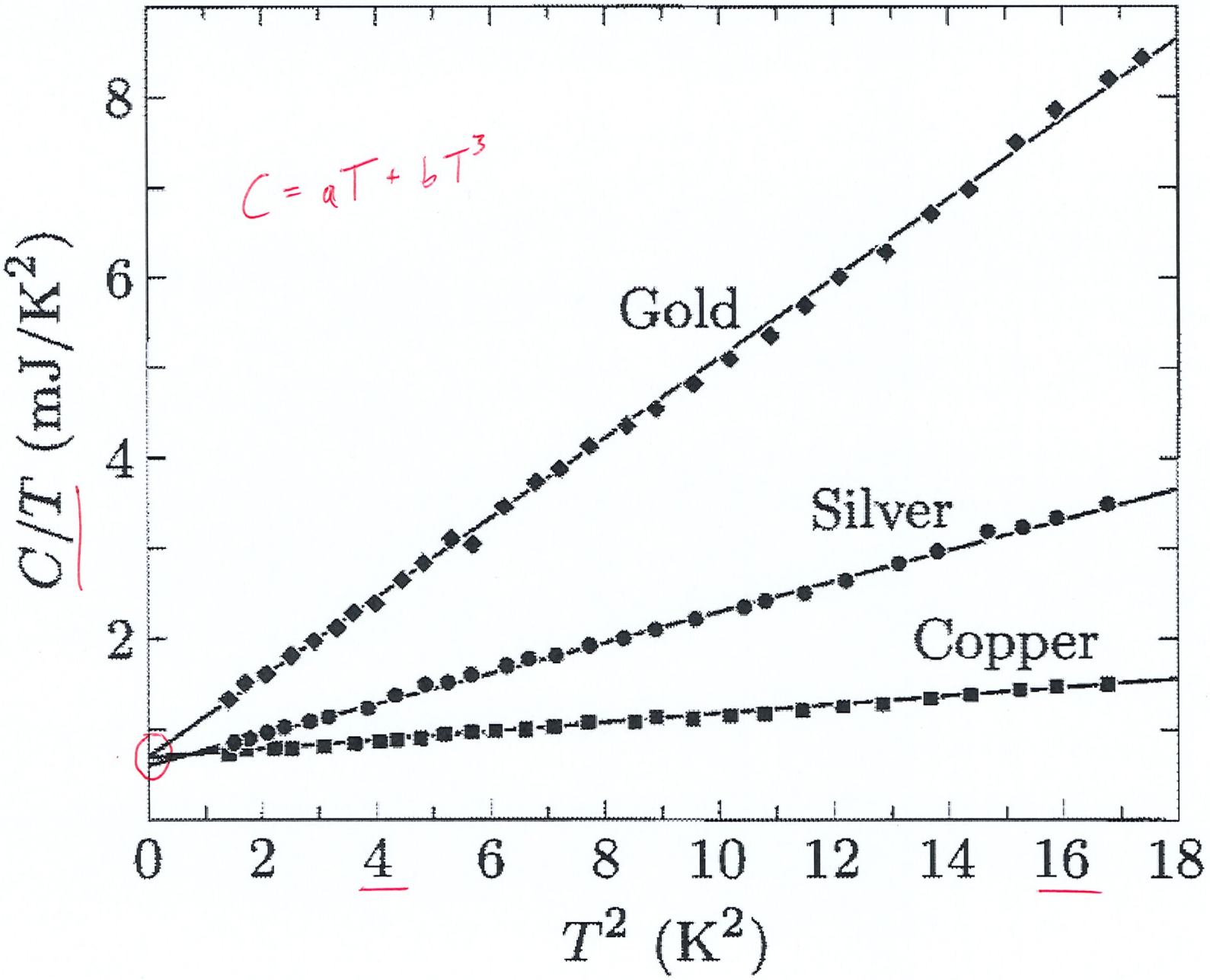
Giorgio Parisi

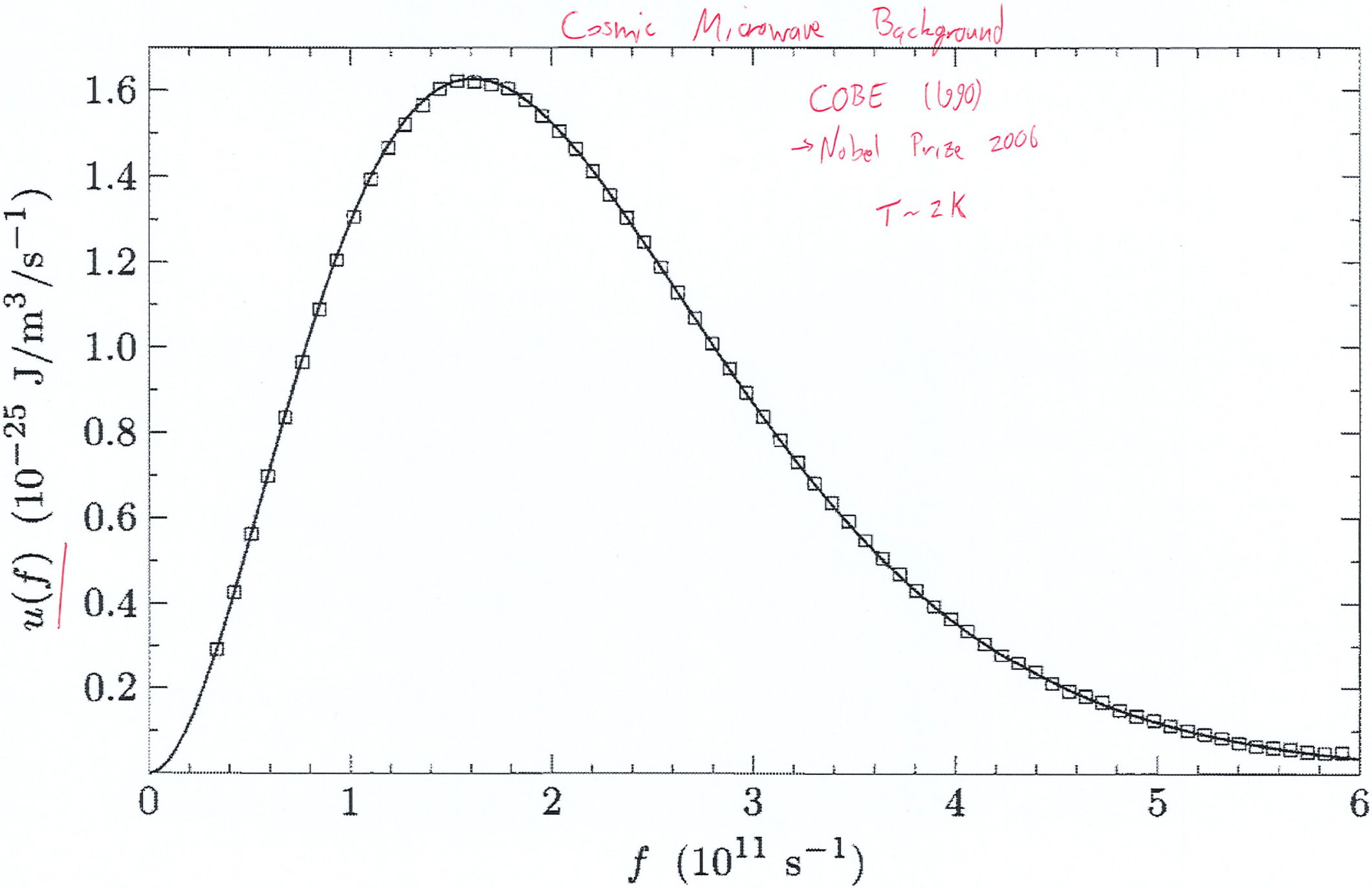
"for the physical modelling of Earth's climate, quantifying variability and reliably predicting global warming"

"for the discovery of the interplay of disorder and fluctuations in physical systems from atomic to planetary scales"

THE ROYAL SWEDISH ACADEMY OF SCIENCES


Heat capacity (J/K)
25
20
15
10
5
Lead
Aluminum
Diamond
100
200
300
400
T (K)


$C = aT + bT^3$
Gold
Silver
Copper
C/T (mJ/K^2)
T^2 (K^2)
0
2
4
6
8
10
12
14
16
18
2
4
6
8


Cosmic Microwave Background
COBE (1990)
→ Nobel Prize 2006
T ~ 2K
$u(f)$ $(10^{-25}$ J/m^3/s$^{-1})$
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
1
2
3
4
5
6
f $(10^{11}$ s$^{-1})$

Big picture

Stat. Phys. (late 1800s) + Relativity + Quantum (early 1900s)

↓

LARGE #s of "particles"

1 c.c. of water ~ 10^{22} H_2O molecules

Snapshot: ~ 10^{22} × (position + momentum) × 3 × 4B ~ 10^{23} bytes of info

10^{11} TB

(hundred billion)

Dynamics: ~ 10^{22} coupled diff. eqs

Consequence: Emergent phenomena

Probability foundations

Emergence of smooth large-scale behaviour

→ Law of large numbers

Central limit theorem

Build up from definitions...

Random experiment $\mathcal{E}$ observes world

→ state ω (omega)

$\Omega = \{\omega\}$ is set of all states for experiment $\mathcal{E}$

Measurement $X(\omega)$ extracts info. of interest

$X: \Omega \to A$ outcome space

Finite, countable or continuous

Repeat $\mathcal{E} \to X(w_i)$ is random variable