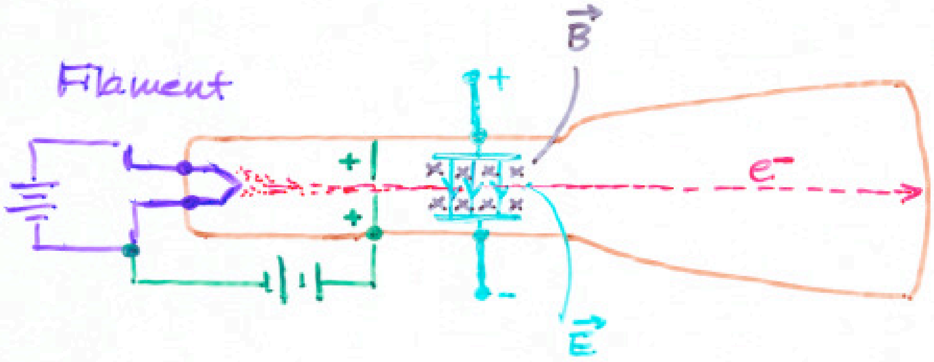
CHAPTER 3

EXPERIMENTAL BASIS OF QUANTUM THEORY...

my take!

let's clean up some details from the historical introduction

- Electron Discovery – multiple experiments by Thompson



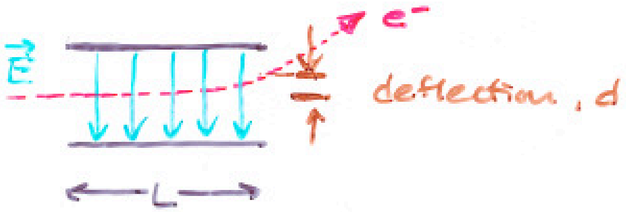
from $$\vec{F} = -\underset{\substack{\uparrow\\ \text{up}}}{q\vec{E}} - \underset{\substack{\uparrow\\ \text{down}}}{q\vec{v}\times\vec{B}}$$ } PRESUME A NEGATIVELY CHARGED PARTICLE

By adjusting $|\vec{E}|$ and $|\vec{B}|$ can cause "beam" to be un deflected → straight-ahead

- adjust to hit where $\vec{E}=0$; $\vec{B}=0$ beam hit then $$qE = qvB$$

$$v = E/B$$ a measure of the velocity

let just the $\vec{E}$ field deflect the beam -- $\vec{B} = 0$.



uniform acceleration through L region:

$$d = \frac{qEL^2}{2mv^2}$$

or:

$$\frac{q}{m} = \underbrace{\frac{2dv^2}{EL^2}}_{\text{known}}$$

$$\frac{q}{m} \simeq 2 \times 10^{-11} \ C/kg$$

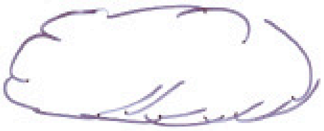
- He also did H^+ ions and found $\frac{q}{m} \doteq 10^{-14}$ C/kg.
- found charge of q from bend direction
- found v -- used later for m(v) measurements.

Why Thomson? tubes had been around --

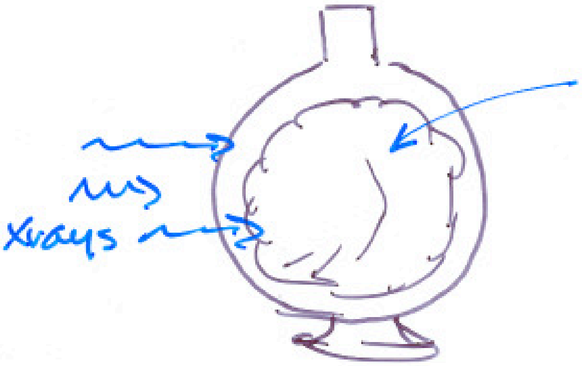
1. Vacuum. Poor vacuums messed up other attempts to see electrostatic deflection
2. mind-set.

CHARGE!

Thompson also had a scheme for determing q.



cloud: water vapor condensed onto dust or other nucleating matter



creates ions -- reduced pressure
↓
drops
↓ which fall

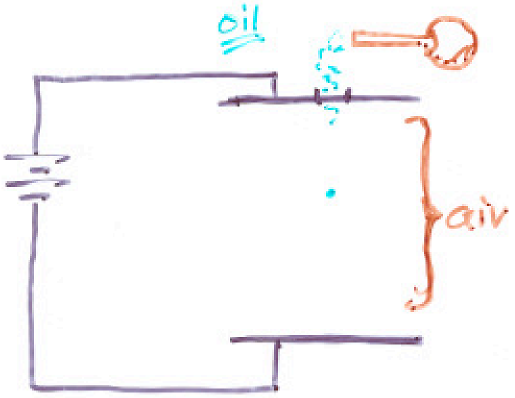
He counted drops and measured the electrical conductivity of the vapor

-- crude measurement

"dissatisfied" with Thomson's results,

Robert Millikan

took the idea to an extreme of precision. 1906.



adjust the $\vec{E}$ field to counteract gravity

mass of drop, measured by watching it fall in viscous medium by measuring speed.

$$qE = mg$$

total charge on the drop

- lots and lots of charges, different on each drop.
- analyzed for a $\underbrace{\text{common factor}}_{\text{the fundamental unit of charge}}$ for each charge

"e" ~ 1% measurement by him.

then, 10^{-3} precision.

$$e = (1.60217733 \pm 0.000\,000\,49) \times 10^{-19}\,C$$

BLACK BODY RADIATION

1879 Stefan measured

$$R_B = \sigma T^4$$

R_B - power radiated by blackbody per unit area
-- "radiant emittance"

σ - constant, Stefan's Constant

$\sigma = 0.56686 \times 10^{-7}\ W/m^2K^4$

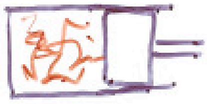
T - temperature of blackbody, K.

5 years later, Boltzmann showed this thermodynamicall

Maxwell had shown that EM radiation produces a pressure

For an energy density of $u(\lambda, T)$, the total energy density would be $u_{tot}(T) \equiv \int u(\lambda, T)\, d\lambda$

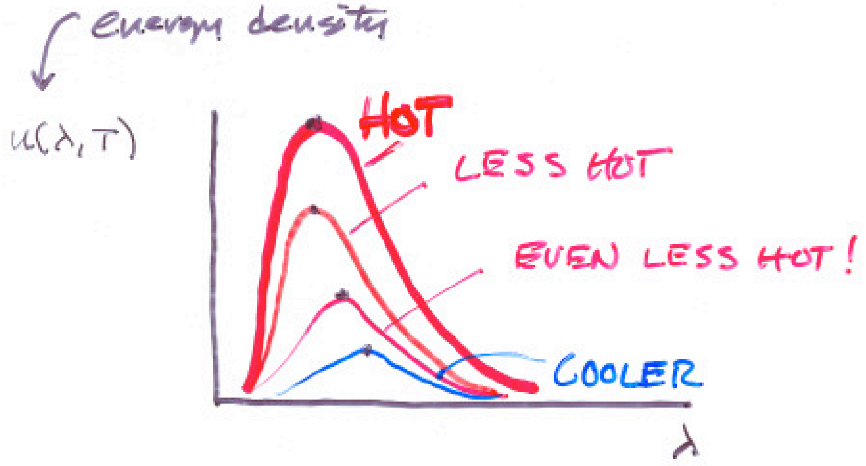
radiation pressure proportional



calculated pressure against a piston:

$$u_{tot} = \sigma T^4$$

FROM EXPERIMENT:



all materials (pretty much -- all blackbodies)

Wilhelm Wien ~ early 1880's

two phenomenological results

1. Wien's displacement law...

the peaks of the curves are at different λ

$$\lambda_{max} \cdot T = \text{constant} = 2.898 \times 10^{-3} \text{ m} \cdot \text{K}$$

2. Wien's Radiation law.

From Boltzmann's statistical ideas

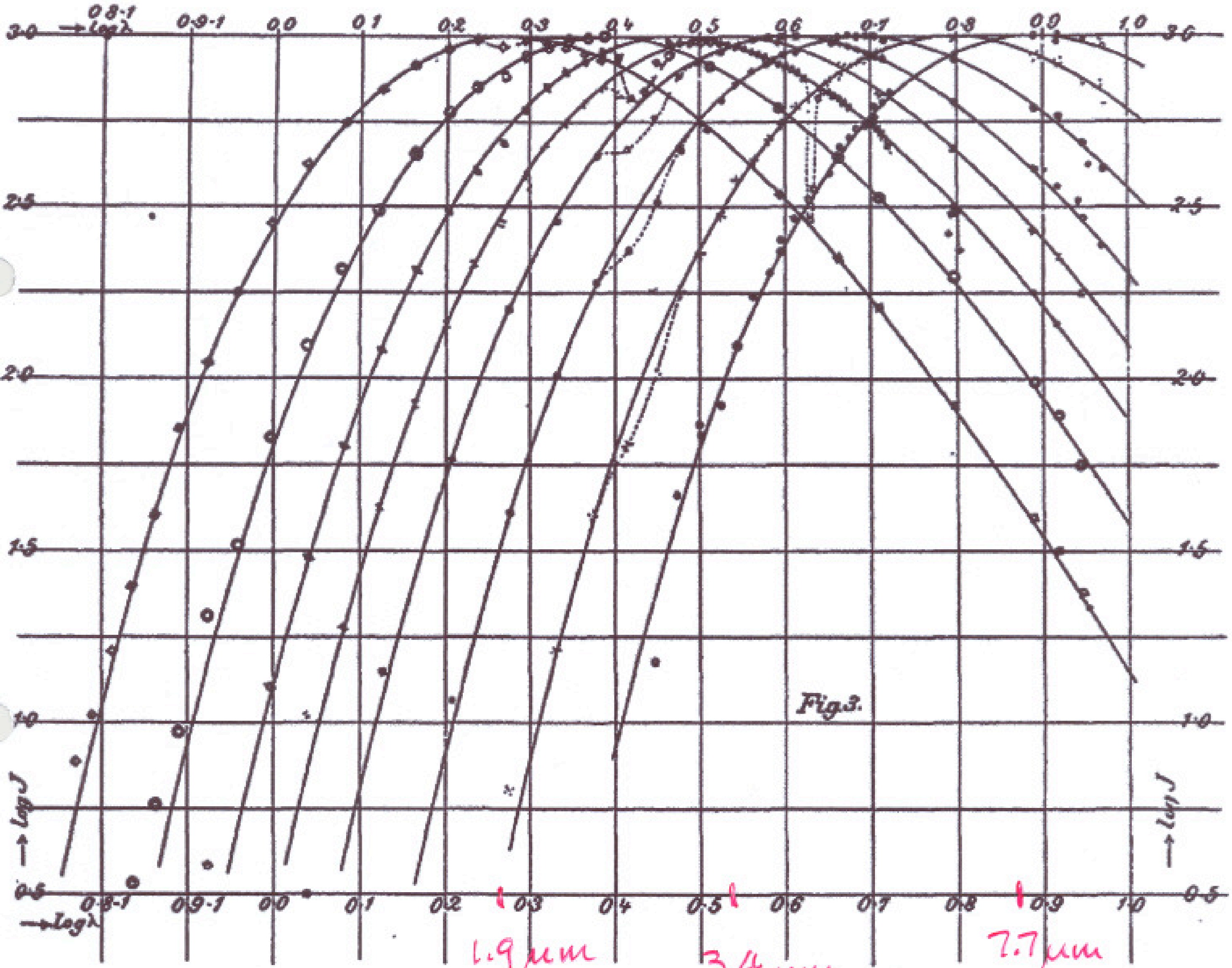
+

assumptions which were <u>not</u> justified

$$I_{Wien}(\lambda, T) = b \lambda^{-5} e^{-a/\lambda T} = b f^{3} e^{-\alpha f T}$$

a, b, α to be determined from experiment

→ not a physical theory! Thermodynamics & EM.



1.9 µm

3.4 µm

7.7 µm

FIG. 3.

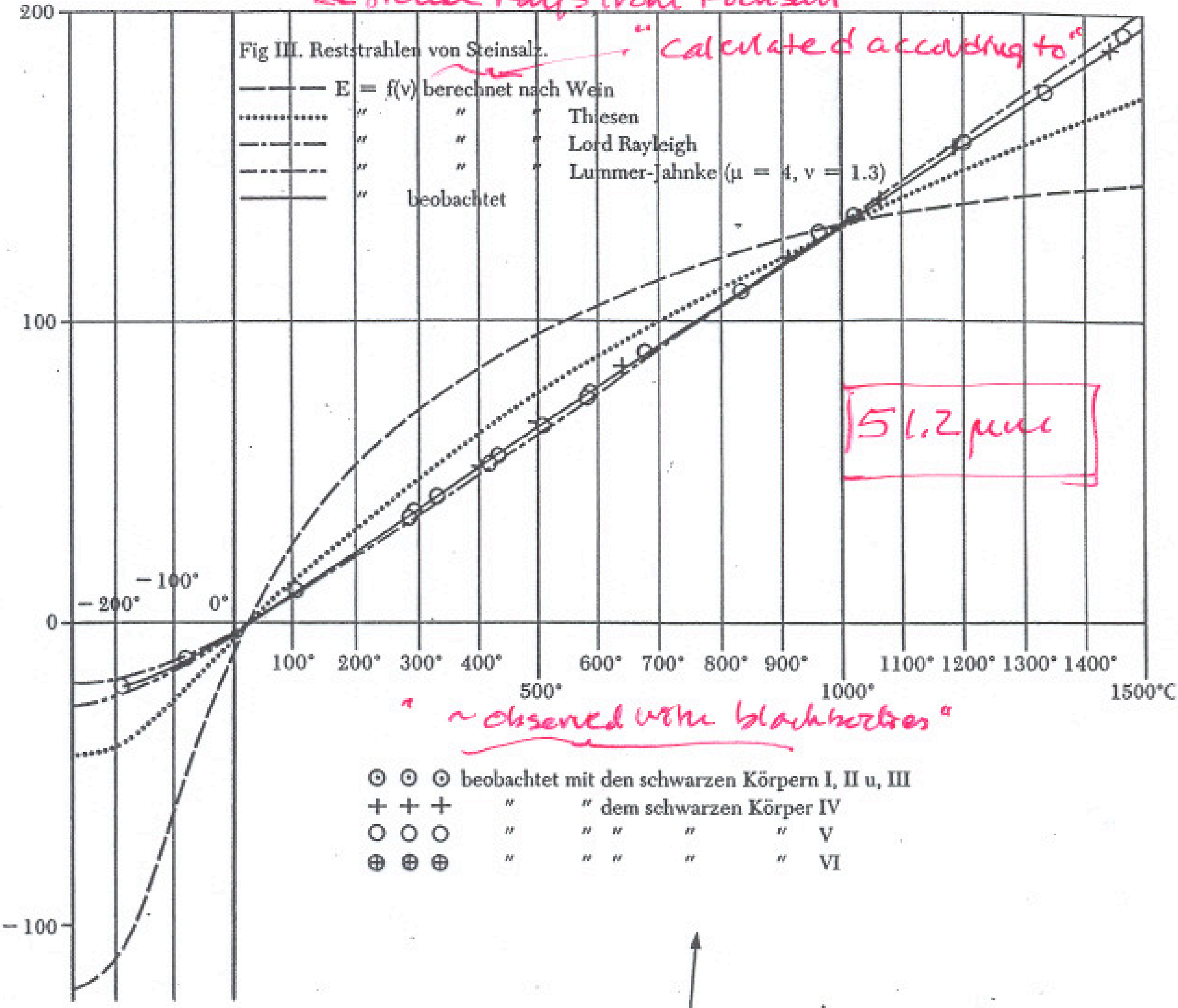


Fig III. Reststrahlen von Steinsalz.

"Residual Rays from Rocksalt"

"calculated according to"

"~ observed with blackbodies"

51.2 μm

[redacted]