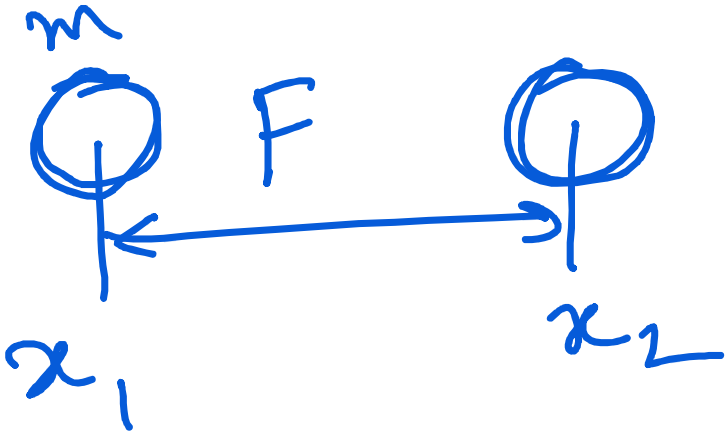
Classical



Newton

$$F = \frac{d\vec{p}}{dt}$$ (Continuous)

Quantum

Smaller particles

Both x & p_x

Atomic Line Spectra

(Discrete)

Max Planck (1900)

Blackbody Radiation

$E = h\nu$

h ← Const.

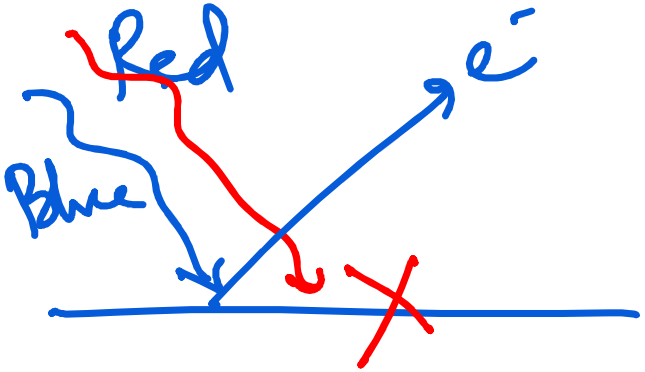
6.62×10^{-34} Js

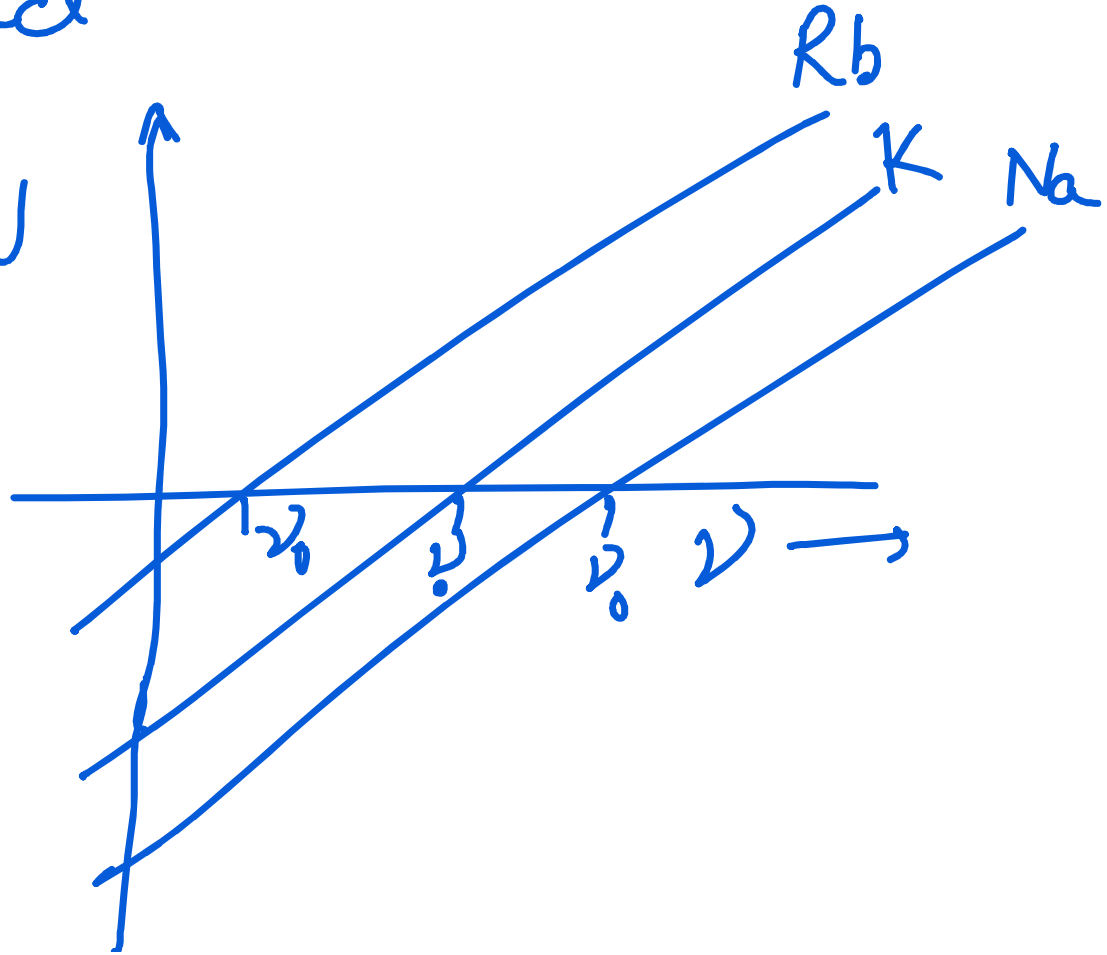
Discrete

"packets" ⟷ "quanta"

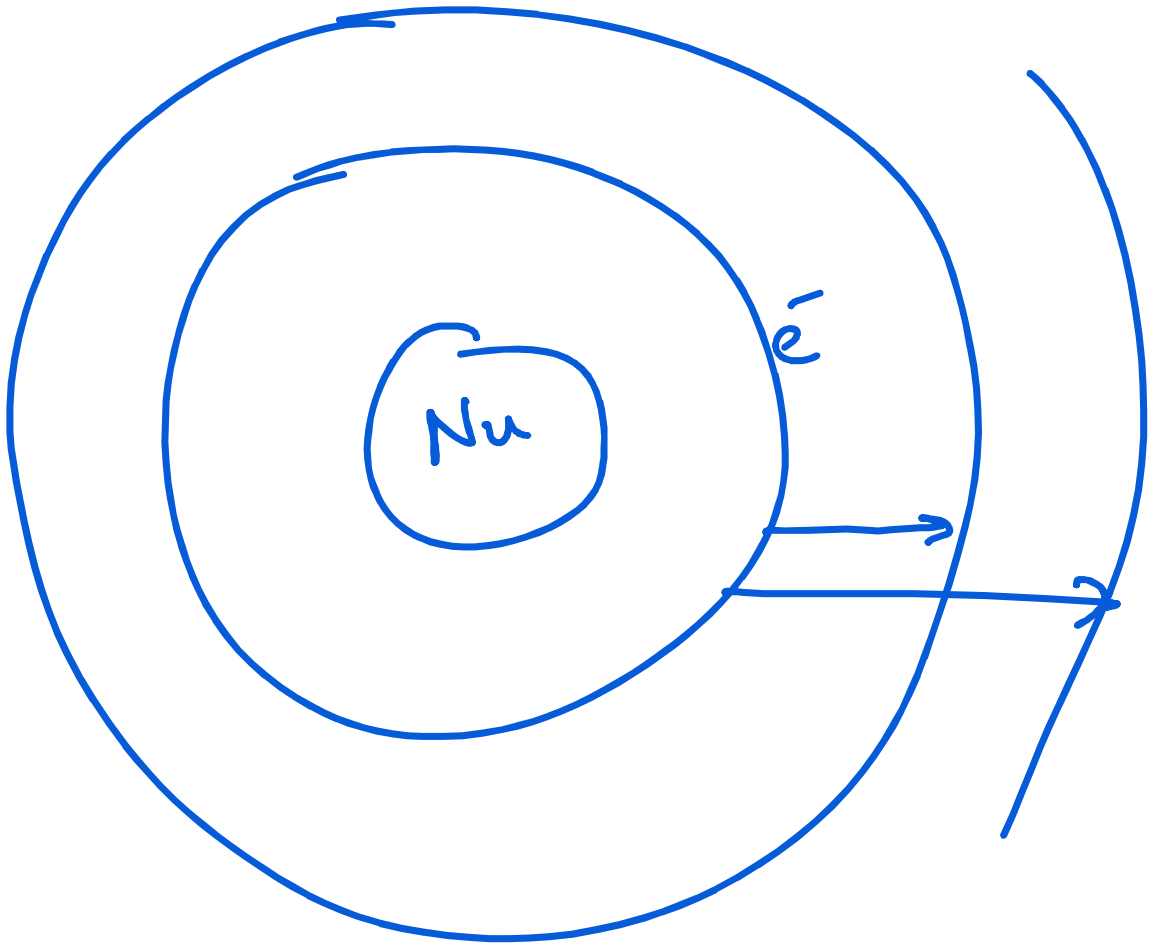
Einstein (1905)

Photoelectric effect





$$E = h\nu - h\nu_0$$



"h" → fundamental Const

J_s

Particles & Waves → de Broglie

duality

λ of a particle

Wavelength

$$\lambda = \frac{h}{p}$$

Cricket ball

Wave like properties

Davidson & German (1927)

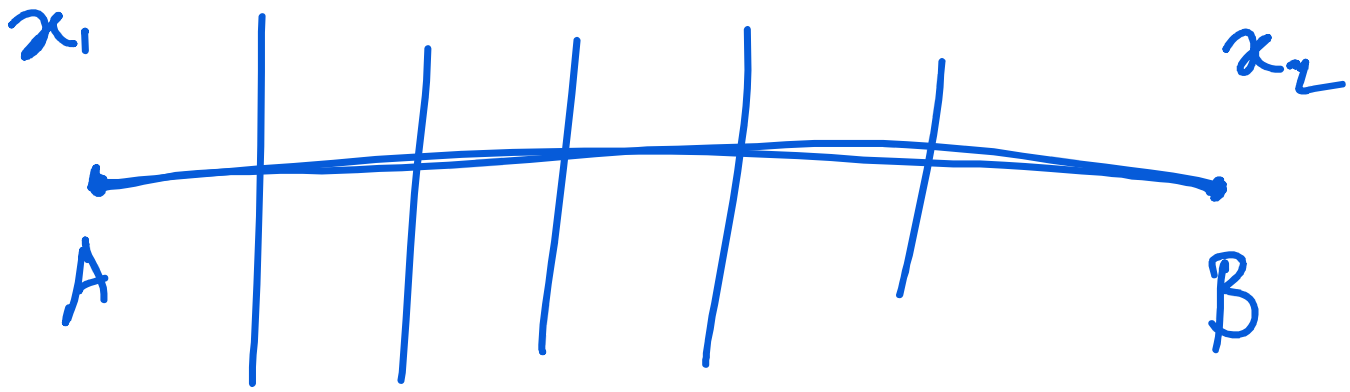
Small particles vs large Observation

Heisenberg Uncertainity Principle

$$p \longrightarrow \Delta p$$
$$x \longrightarrow \Delta x$$

$$\Delta p \cdot \Delta x \geq \frac{\hbar}{2}$$

$$\hbar = \frac{h}{2\pi} \simeq 1 \times 10^{-34} \ J_S$$



ν $\quad$ x_i $\quad$ x_j

p_x

momentum

position

$$\Delta x * \Delta p_x > \frac{h}{2}$$

Chemistry ⟶ Molecules & Structure

"x" e^-

position

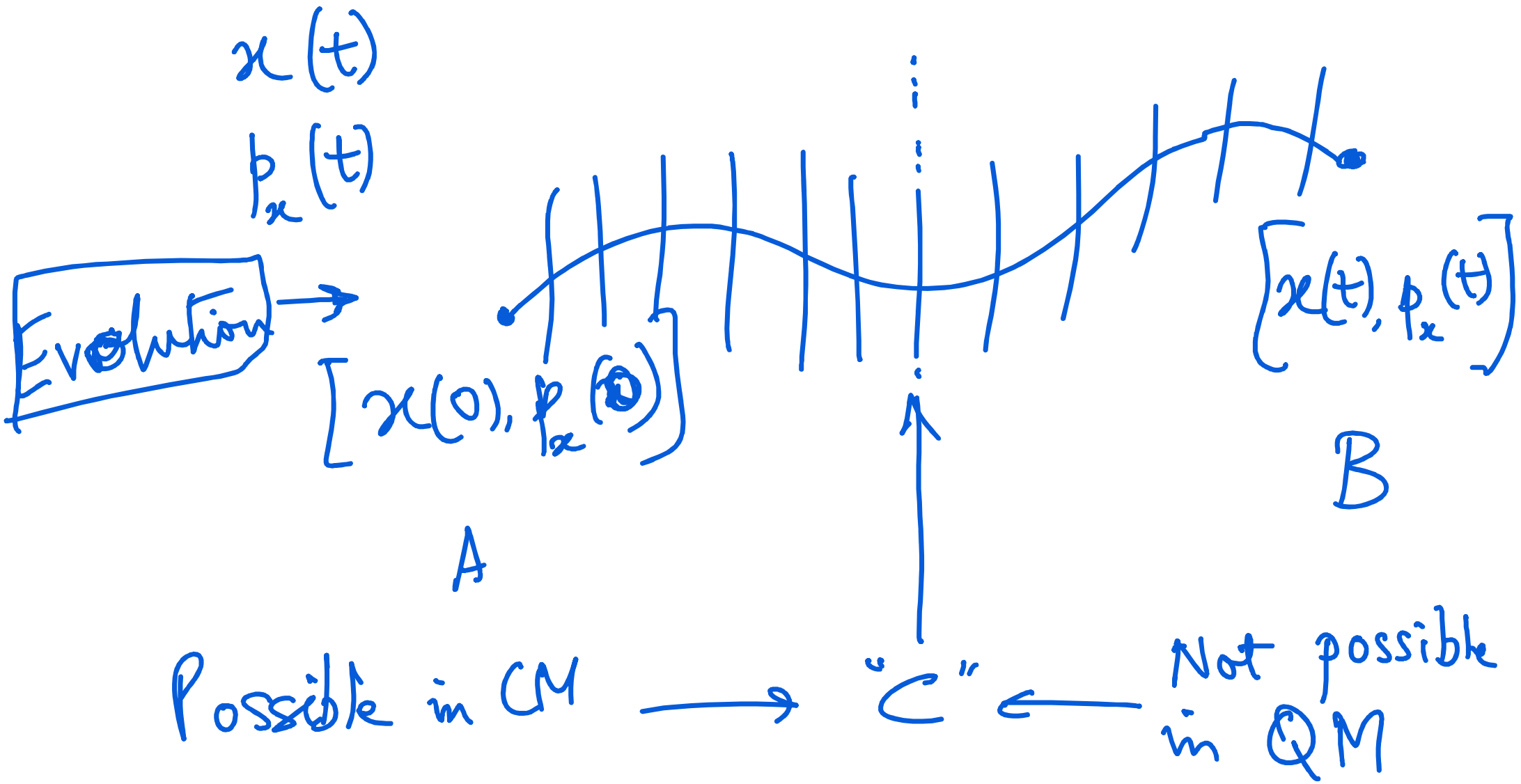
Observable

E

"Spectro"scopy

Continuous

Discrete "E"


x(t)
p_x(t)
Evolution
[x(0), p_x(0)]
[x(t), p_x(t)]
A
B
Possible in CM
"C"
Not possible in QM