Lecture 1

04 September 2024 13:25

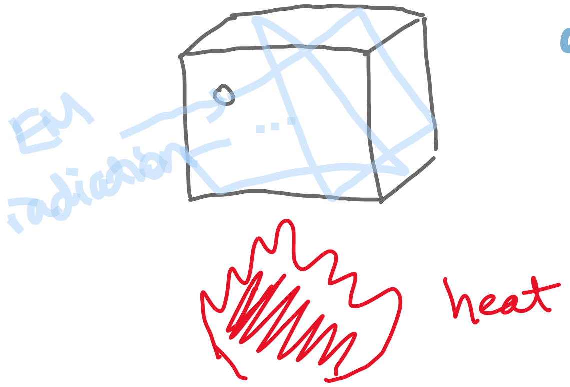
What is "quantum" exactly?

A difficult question, but, one aspect that differs from classical mechanics is <u>quantization</u>.

specifically, energy quantization

<u>Black-body Radiation</u>

<u>Black-body</u>: a body that emits and absorbs electromagnetic radiation without favouring any wavelengths.



an experimental construction

→ measure radiation that is emitted

Postulate: a blackbody is as good at absorption as emission

but, this would violate the second law of thermodynamics!

Many entities are approximate black-bodies, including humans!

$$E(T) = \int^{\infty} \rho(\lambda, T)\, d\lambda$$

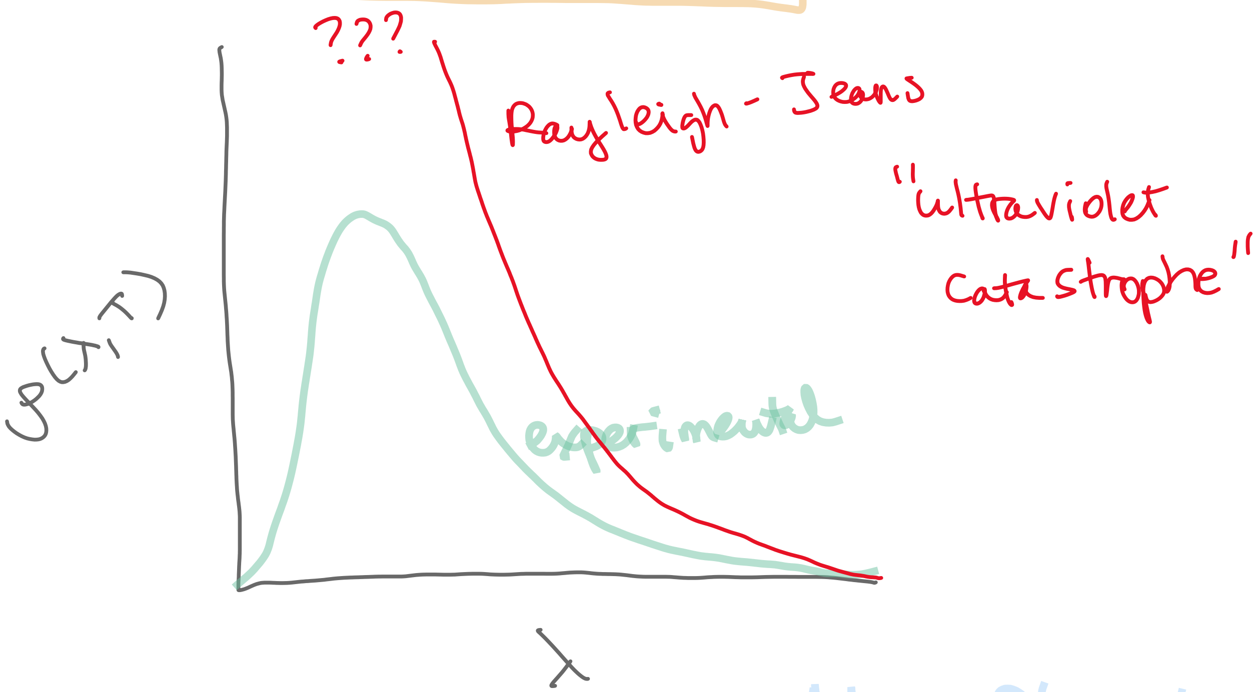
$$E(T) = \int_0 \rho(\lambda, T)\, d\lambda$$

↑ energy density

↑ energy spectral density

$$\rho(\lambda, T) = \frac{8\pi k_B T}{\lambda^4}$$

Rayleigh - Jeans Law



Max Planck

energy quantization : $E = nh\nu$

$n = 0, 1, 2, \ldots$

h: Planck's constant

Boltzmann distribution : $p_i \propto e^{-\varepsilon_i / k_B T}$

↑ probability of being in state i

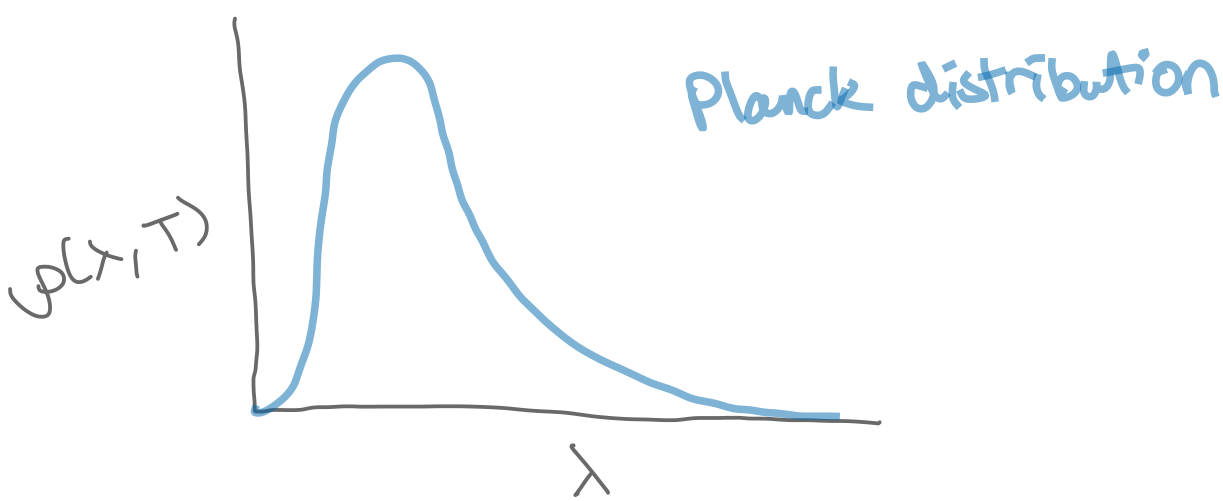
Planck distribution:

$$\rho(\lambda, T) = \frac{8\pi hc}{\lambda^5 \left(e^{hc/\lambda k_B T} - 1\right)}$$

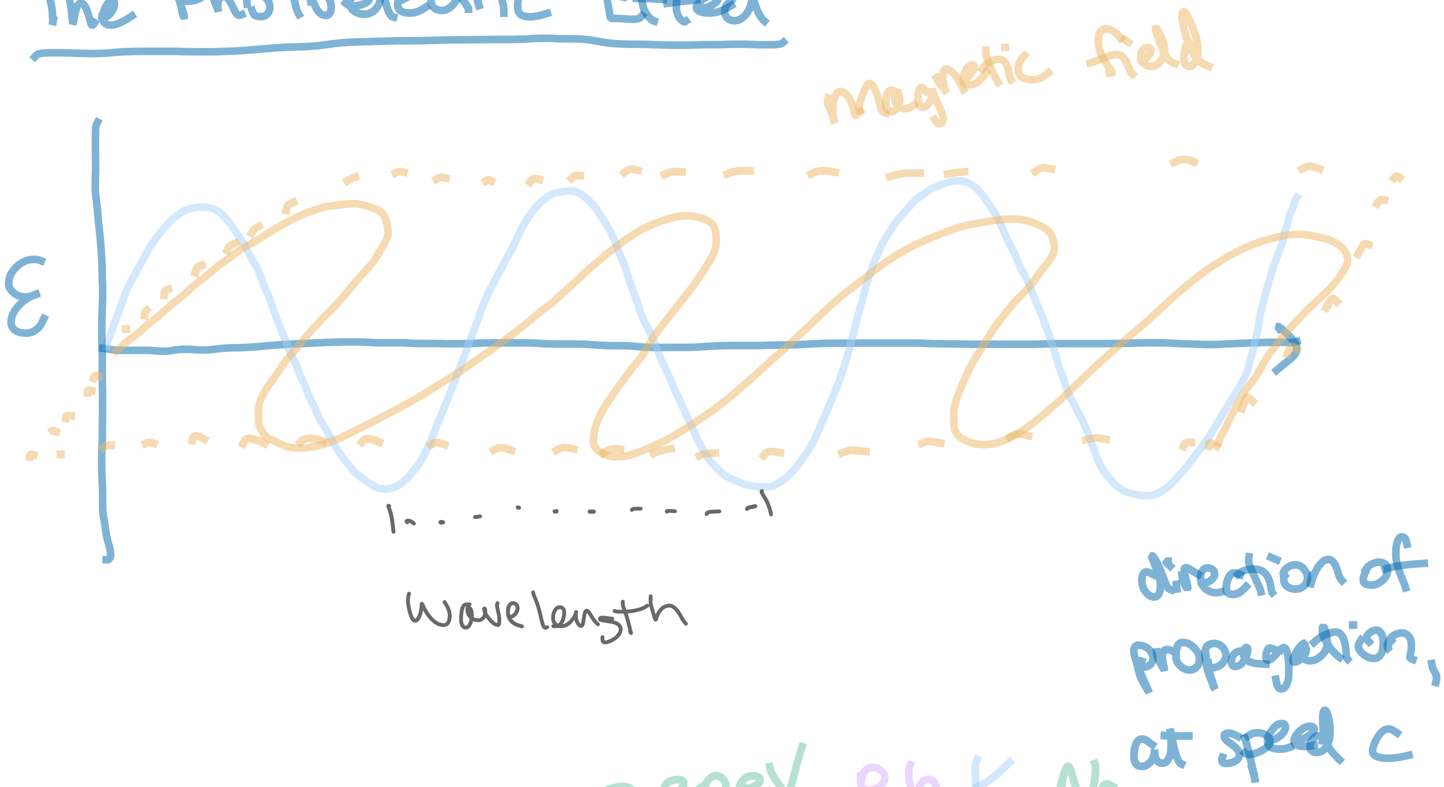
For small λ, $\frac{hc}{\lambda k_B T} \gg 1$

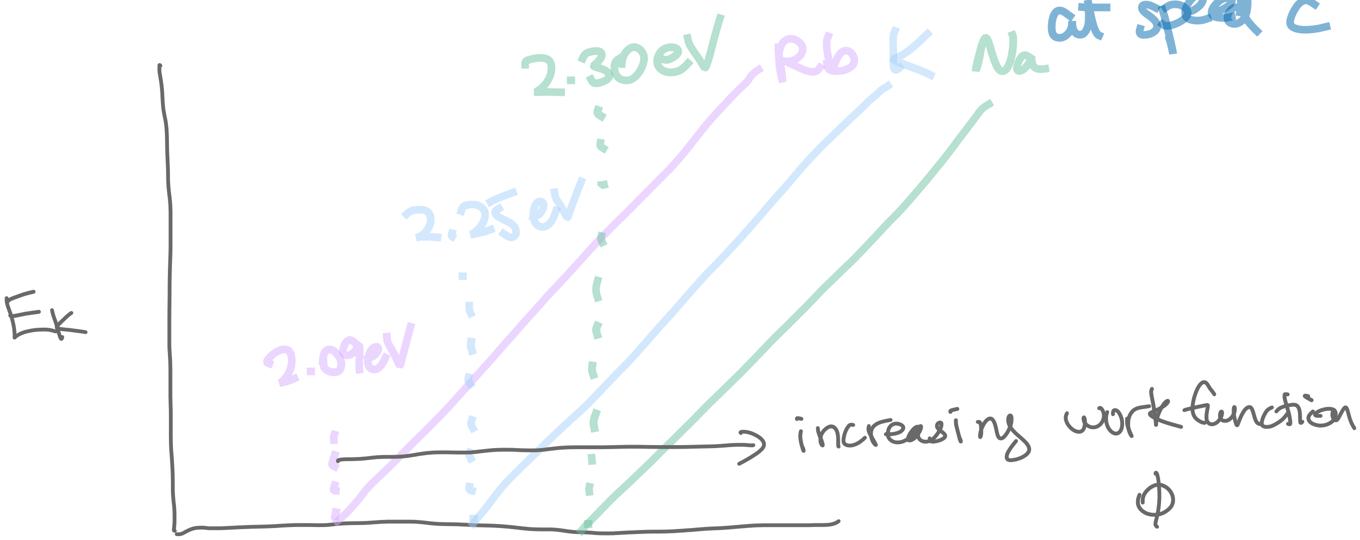
$\lambda^5 \to 0$, but $e^{hc/\lambda k_B T} \to \infty$ faster

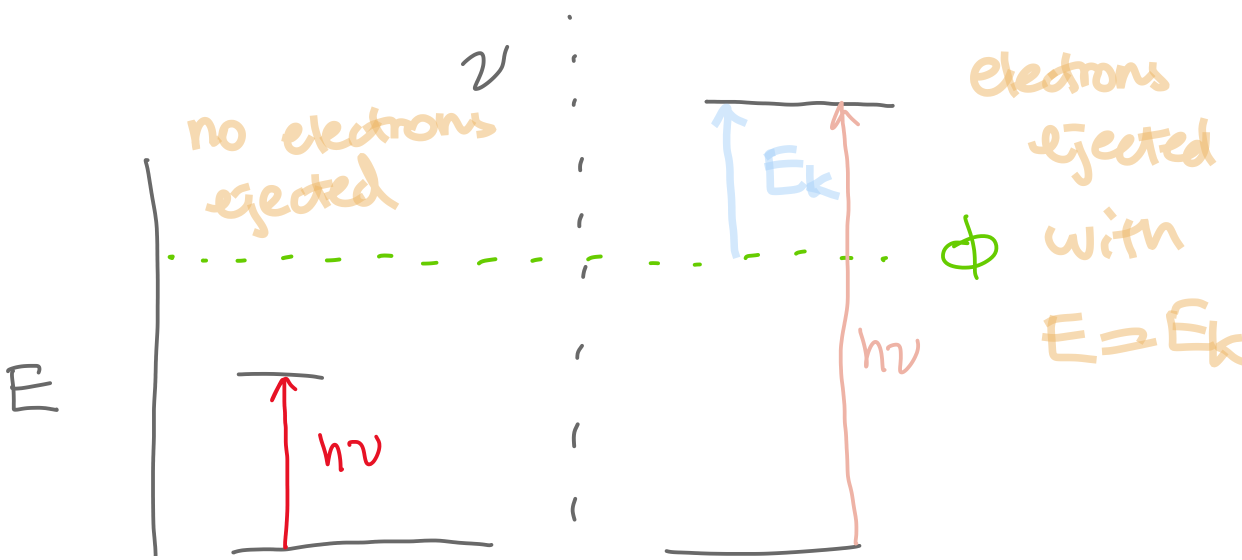
thus $\rho \to 0$ as $\lambda \to 0$.



The Photoelectric Effect







$$h\nu = E_K + \phi$$

Light has particle-like characteristics in addition to wave-like characteristics!

Double-Slit Experiment

Light passed through a double slit produces an interference pattern, characteristic of waves!