Today

I. Last Time
II. Return to History and the Need for Quantum Theory
III. Bohr's Model of the Atom

I. In discussion with Matt you figured out how Planck guessed the black body spectrum. The most important ingredient was that the energy of the light doesn't come in a continuous manner, but rather as discrete packets. These packets' energy is

$$E = hf = \frac{hc}{\lambda},$$

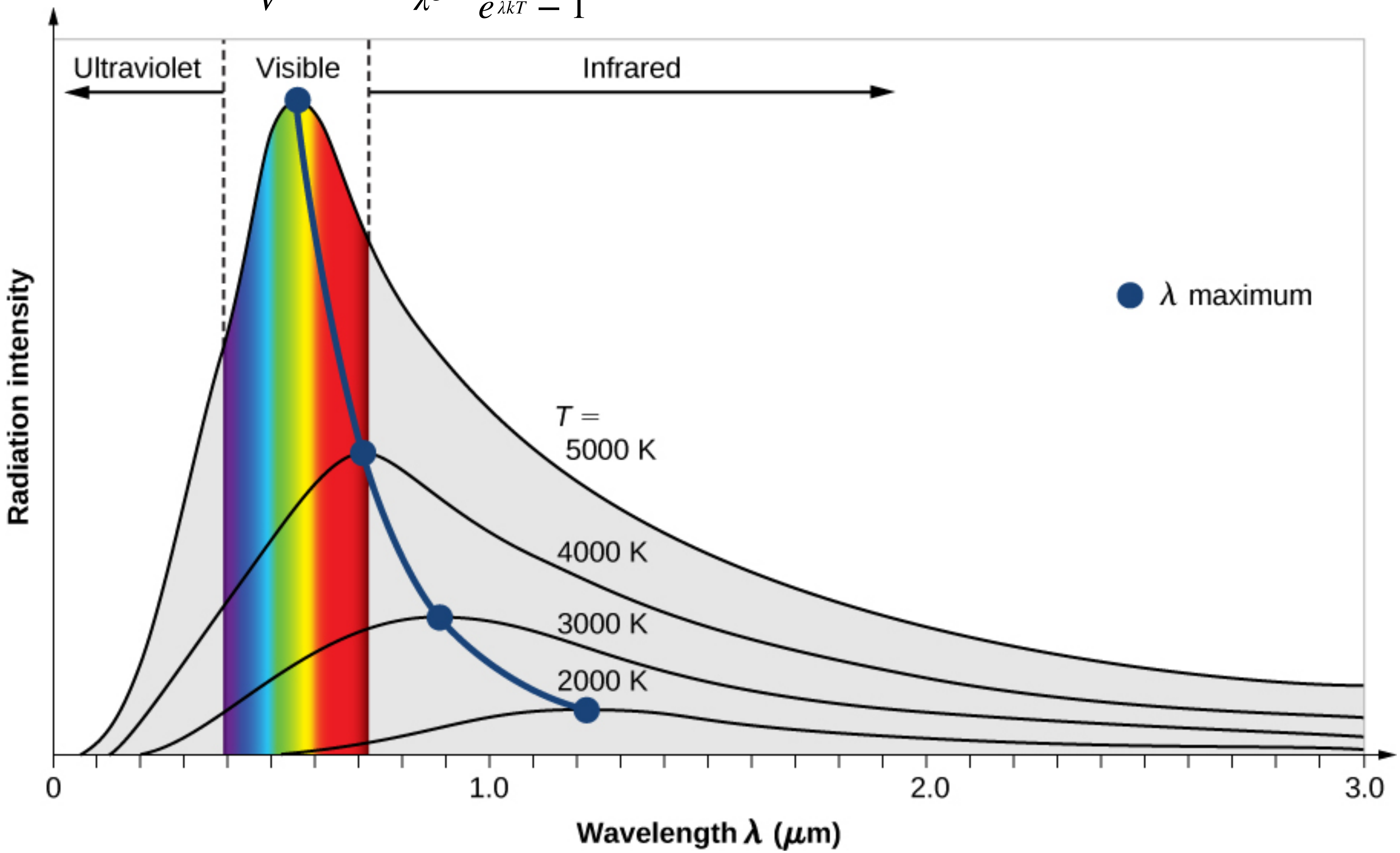
where $h$ is Planck's constant and has the value

$$h = 6.63 \times 10^{-34}\,\text{J s}.$$

This is also often reported in the form $\hbar = \dfrac{h}{2\pi}$.

II. A more careful plot of the black body spectrum and its dependence on Temperature.

$$u(T,\lambda)\cdot d\lambda = \frac{U(T,\lambda)d\lambda}{V} = \frac{8\pi hc}{\lambda^5}\frac{1}{e^{\frac{hc}{\lambda kT}}-1}$$



II. We already reviewed the fact that they knew

Black body radiation results

(1) The Stefan-Boltzmann law:

Power = $\sigma A T^4$ (area of object=$A$) and $\sigma$ is the Stefan-Boltzmann constant

$$\sigma = 5.67 \times 10^{-8}\ W/(m^2K^4).$$

(2) Wien's "Displacement law" locates the maximum energy point of the spectrum

$$\lambda_{\mathrm{max}} = \frac{\alpha}{T},$$

where $\alpha = 2.90 \times 10^{-3}$ m K.

Einstein & the photoelectric effect (1905)

Phenomena is to shine light on a metal surface and you'll see electrons popping off of the metal. Two predictions flow quite naturally out of Planck's hypothesis about packets of light energy:

(i) Increaseing the intensity of the light has no effect on the…

## II. Einstein & the photoelectric effect (1905)

Phenomena is to shine light on a metal surface and you'll see electrons popping off of the metal. Two predictions flow quite naturally out of Planck's hypothesis about packets of light energy:

(i) Increasing the intensity of the light has no effect on the energy of the emitted electrons, but there are more of 'em.

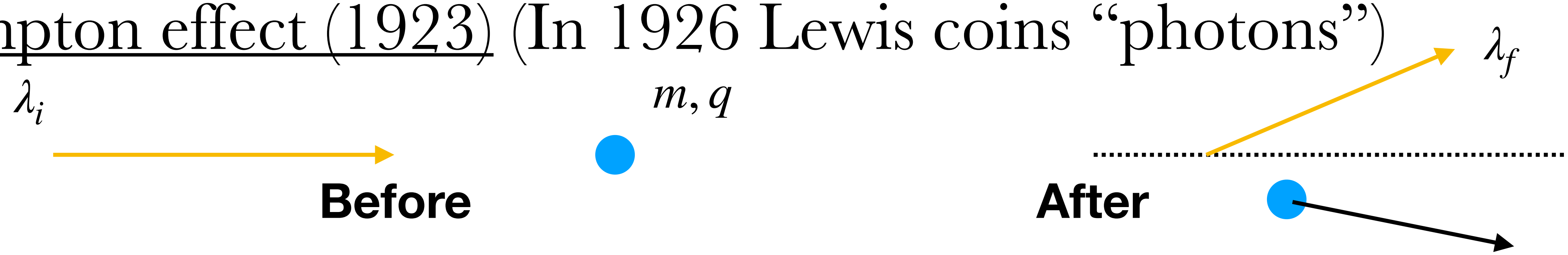
(ii) On the other hand, higher frequency light (i.e. bluer) causes the electron's to depart with more energy.

In the form of an equation, Einstein claimed that you should measure:

$$K.E. = hf - W.$$

Here $W$ is called the `work function' and it is a material specific property that characterizes how hard it is to escape this metal.

Compton effect (1923) (In 1926 Lewis coins "photons")



## II. De Broglie Hypothesis (1924)

If light (a wave) behaves as a particle, maybe particles (e.g. electrons) behave as waves:

$$\boxed{\lambda = \frac{h}{p}} \quad \text{(de Broglie's hypothesis)}$$

Here $p$ is the momentum of the particle. Note: for macroscopic object ($p$ = 1kg m/s, say) $\lambda$ is tiny(!):

$$\lambda = \frac{h}{p} \approx 6 \times 10^{-34} \text{ m.}$$

The instances in which we can't ignore this are when the object is tiny, e.g. atom: $A^\circ = 10^{-10}$m, or nuclei: $10^{-15}$m.

Davisson & Germer (1925)

Electron "diffraction" from a crystal.

Bragg law (constructive interf.):

$2d \sin\theta = n\lambda$,    n=1,2,3,4,....