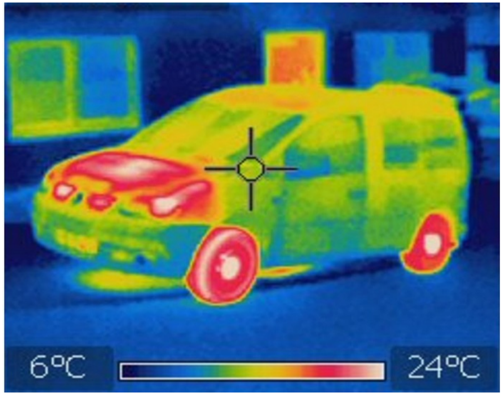
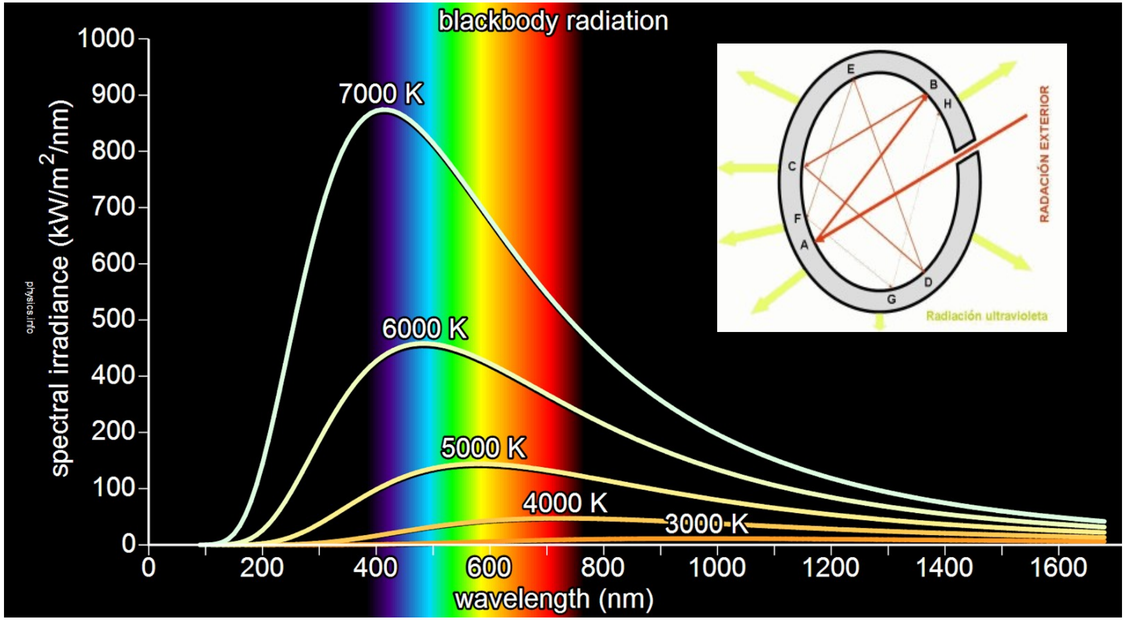
Chapter I
Black body,
Photoelectric effect,
Compton effect and …

. Every hot body emits and absorb radiation
. At low temperature the radiation is in the infrared and can't be seen by human eyes
. But with infrared camera we can distinguish spot with different temperatures



Increasing the body temperature, the emitted radiation become in the visible and it starts from red to yellow to white

Typical spectral distribution of black body

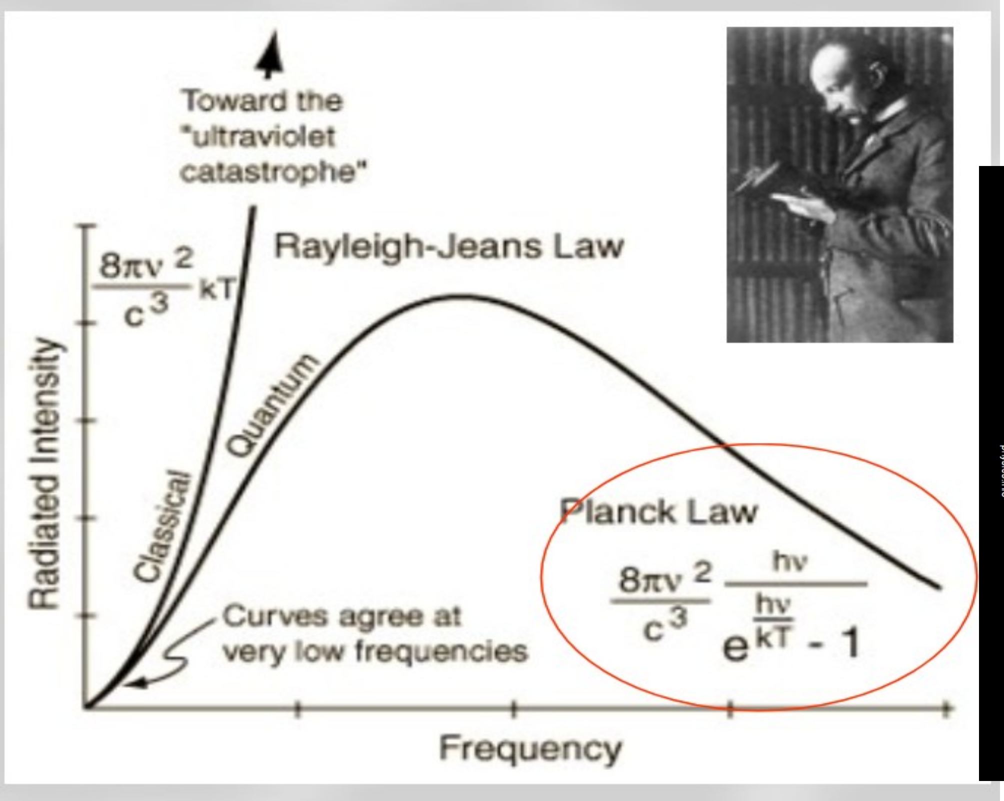


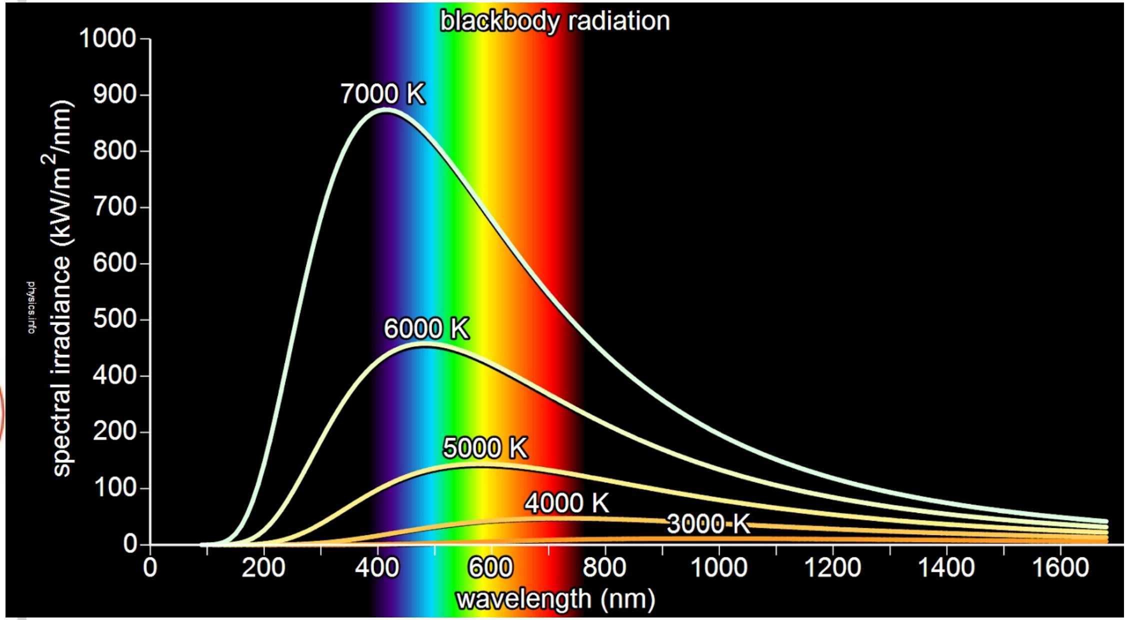
Radiated power per unit area is given by Stefan-Boltzmann law

$$J = \sigma T^4 \qquad \sigma = \frac{2\pi^5 k^4}{15 h^3 c^3}$$

Wien displacement law $$\lambda_{\text{peak}} = \frac{b}{T}$$

b ≈ 2898 μm·K= 2.8977719457849656 mm·K

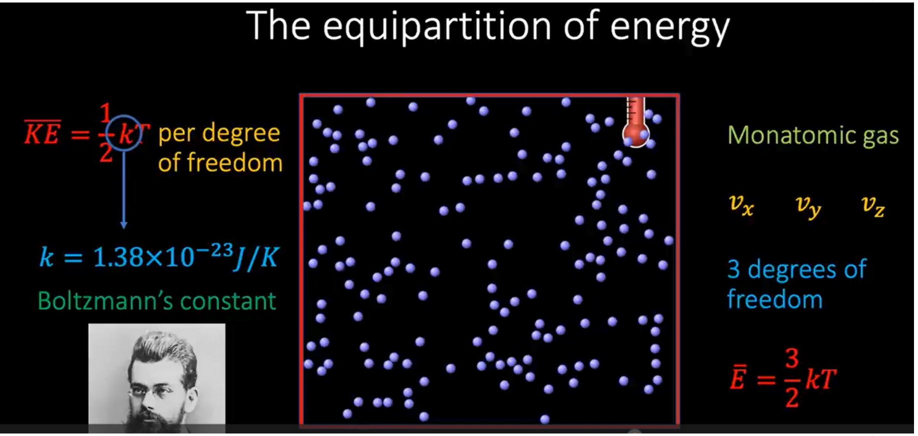


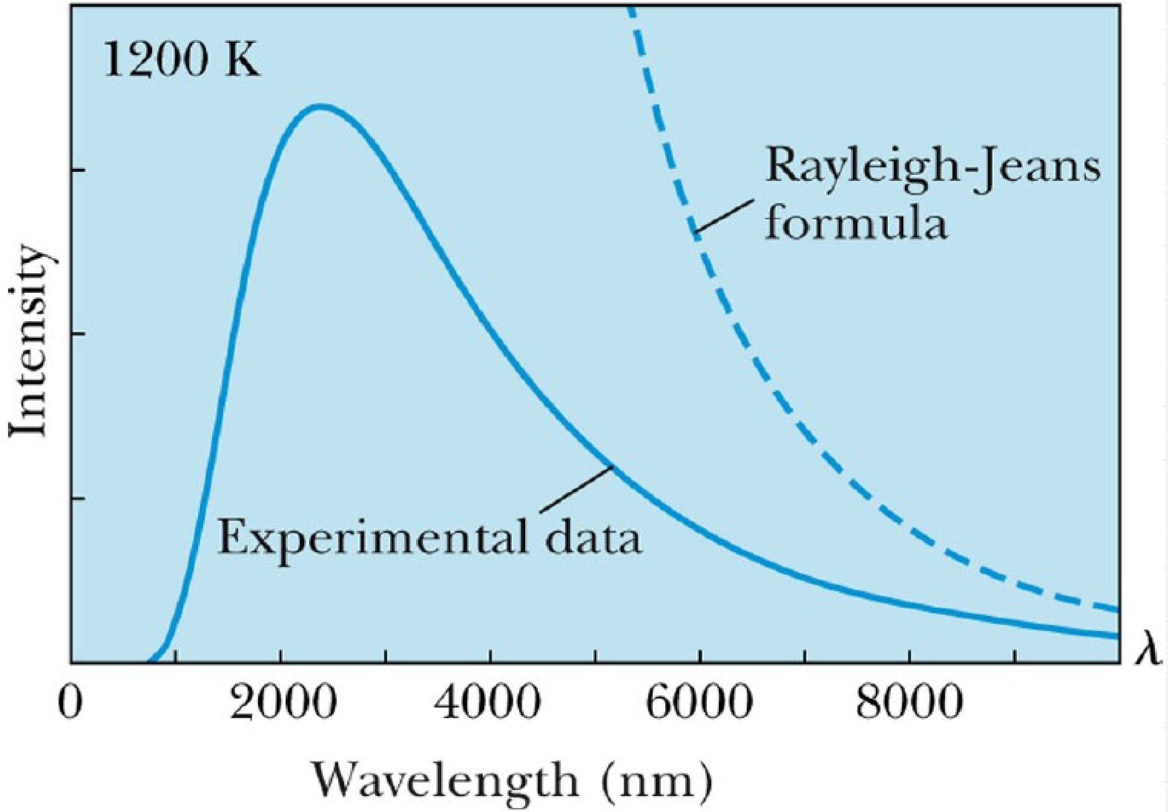


The best description was given by the Rayleigh-Jeans formula

$$I(\lambda, T) = \frac{2\pi ckT}{\lambda^4}$$

This described the distribution at long wavelengths but increased without limit as λ→0 Ultraviolet catastrophe



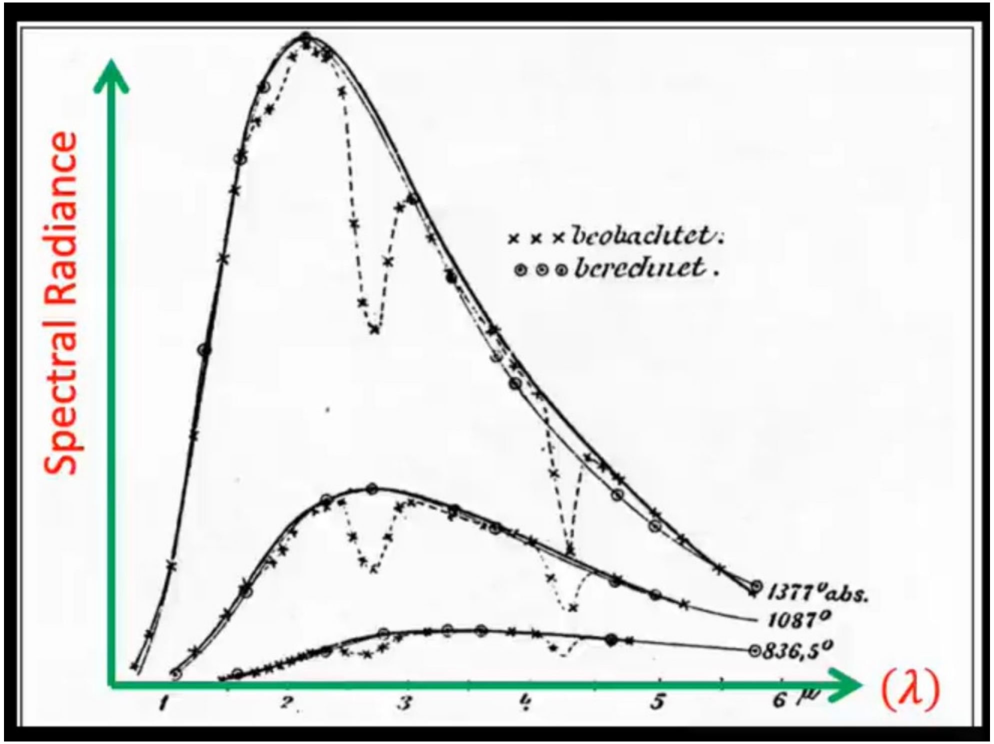


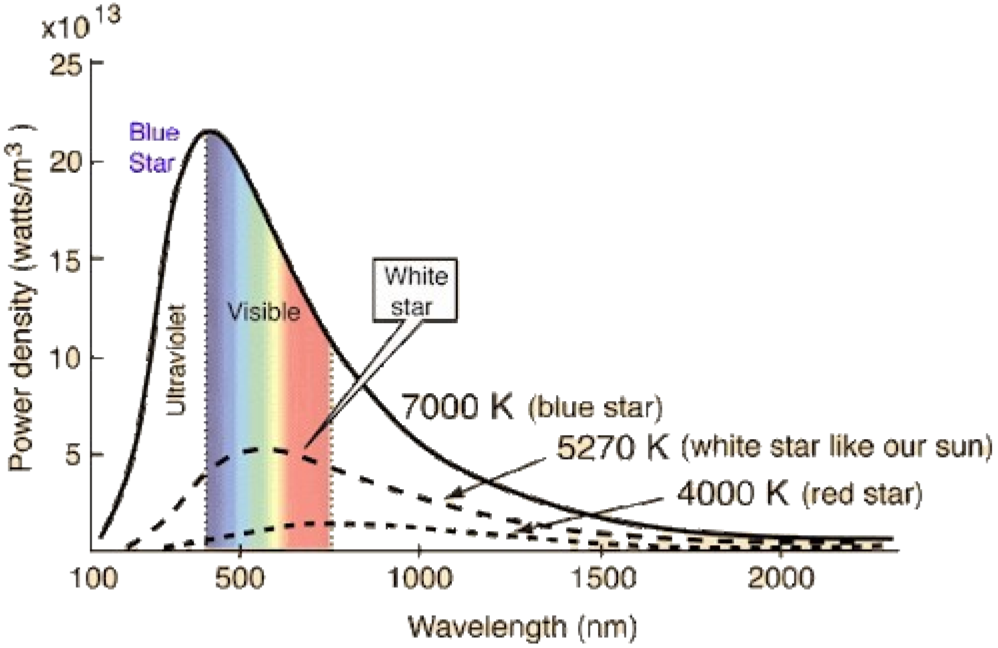
Planck's radiation law

Quanta of energy E=n hf

$$I(\lambda, T) = \frac{2\pi c^2 h}{\lambda^5} \frac{1}{e^{hc/\lambda kT} - 1}$$

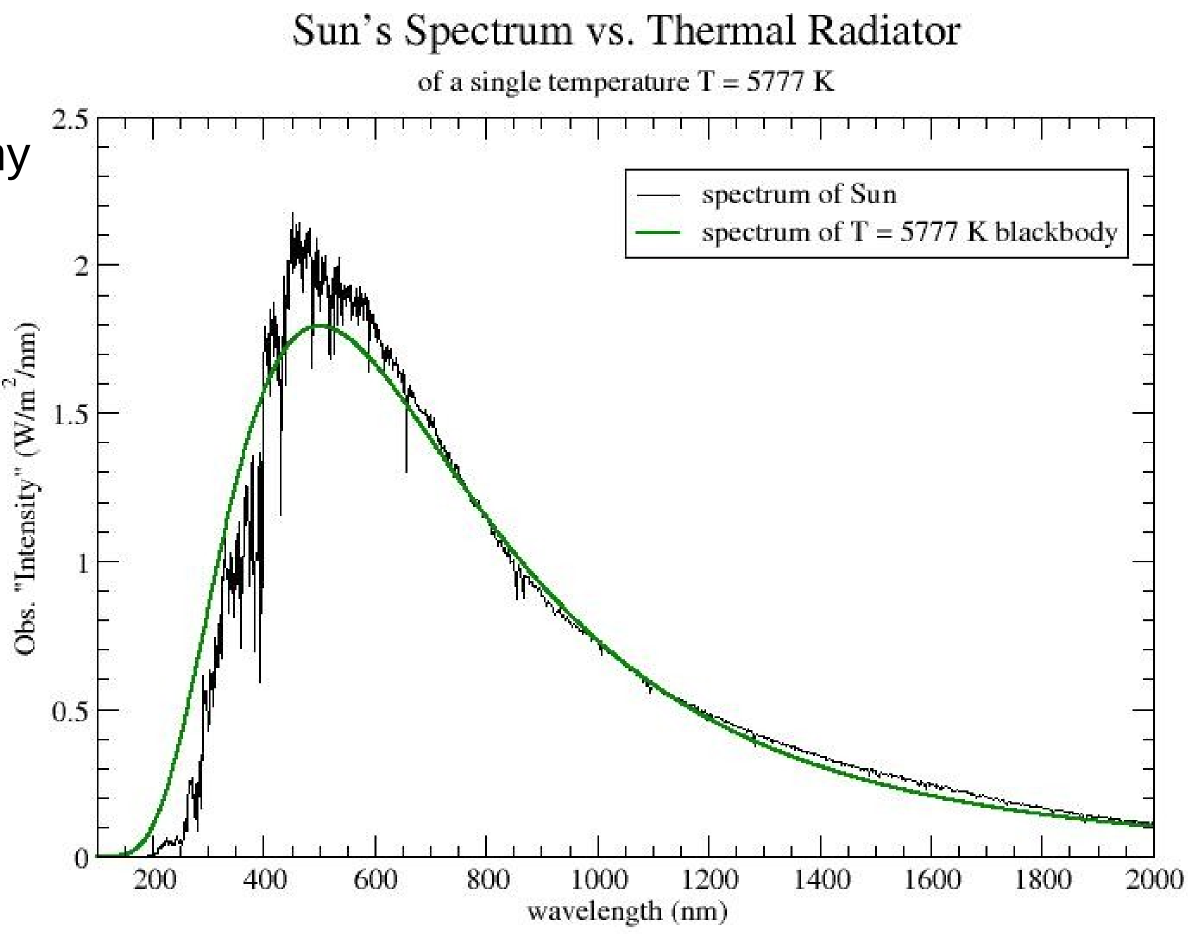
It leads directly to Wien's displacement law and the Stefan-Boltzmann law
It agrees with Rayleigh-Jeans formula for large wavelengths



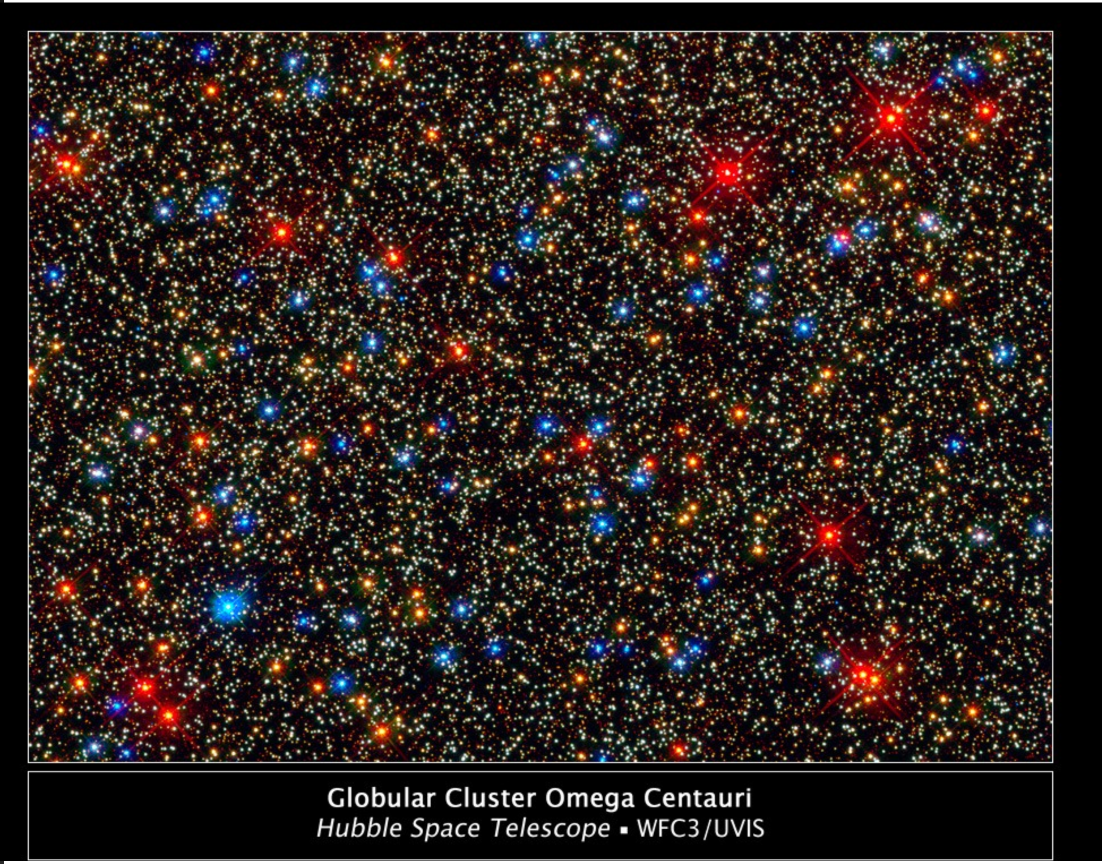


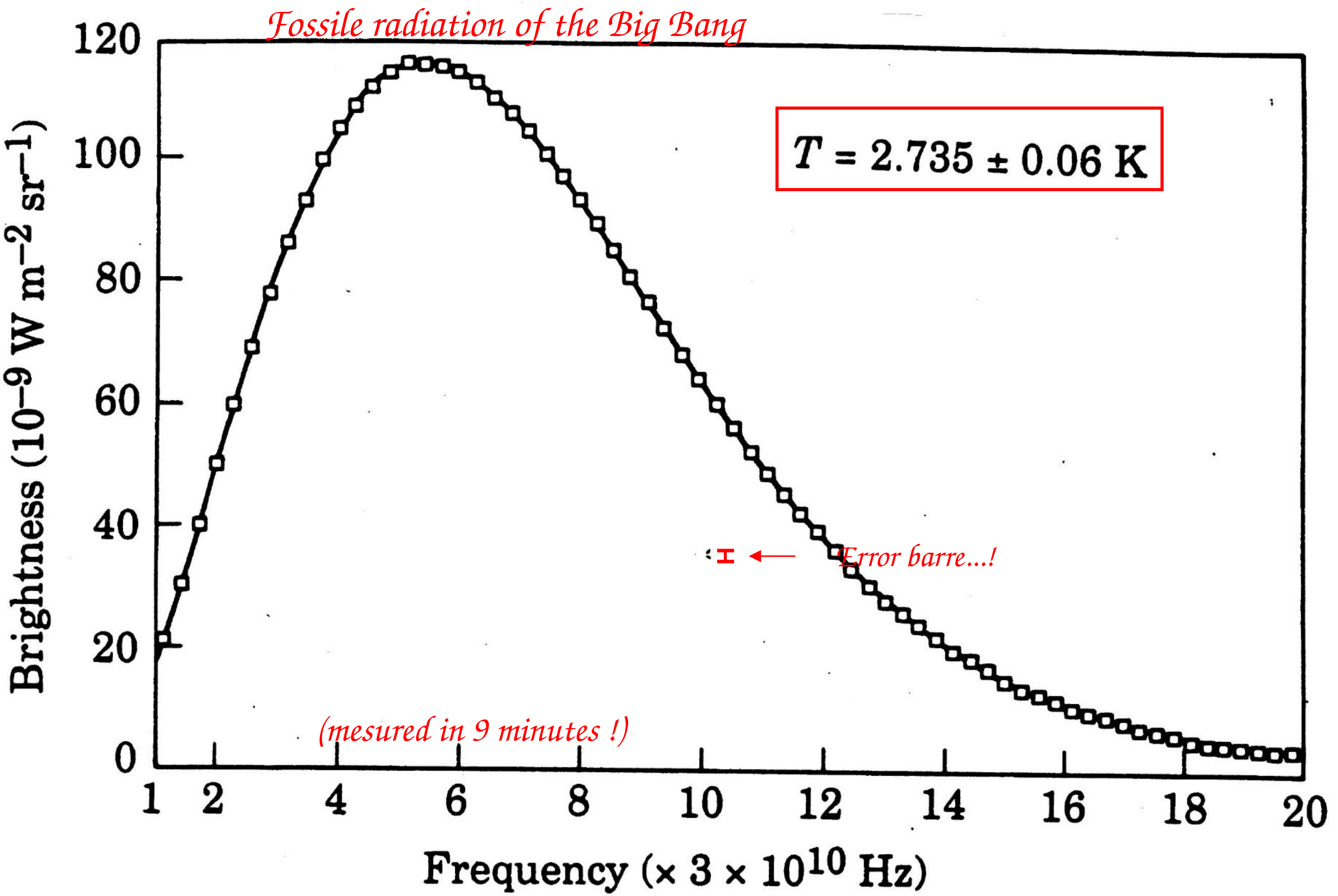
Planck's radiation law

Application to the stars and astronomy



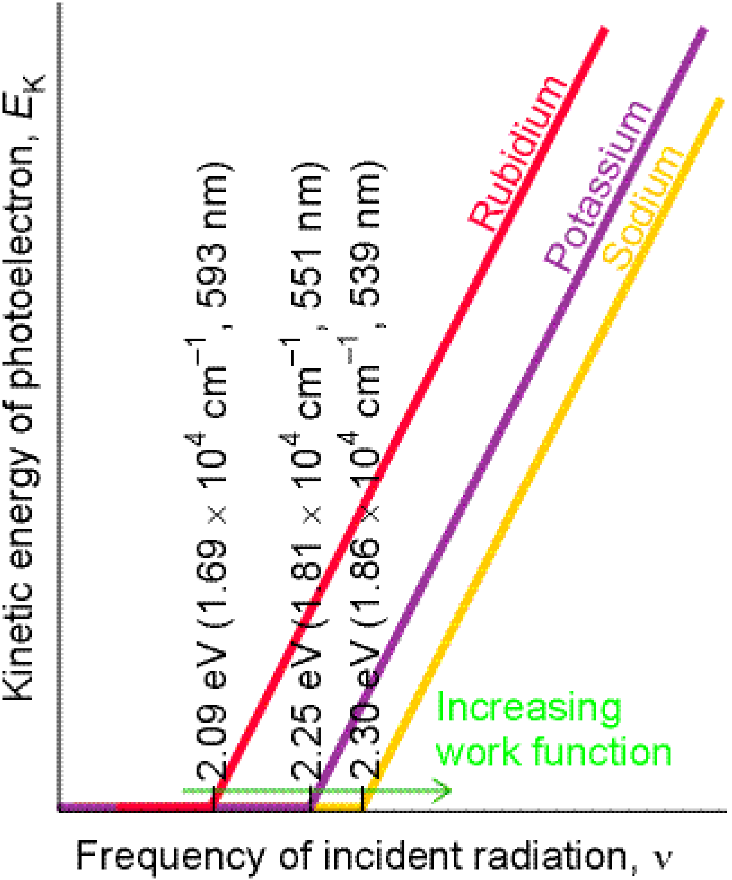
Nom	Type spectral	Température de surface (K)	Couleur
Antares	M	3300	Très rouge
Aldebaran	K	3800	Rouge
Soleil	G	5770	Jaune
Procyon	F	6570	Jaunâtre
Sirius	A	9250	Blanche
Rigel	B	11,200	Bleutée

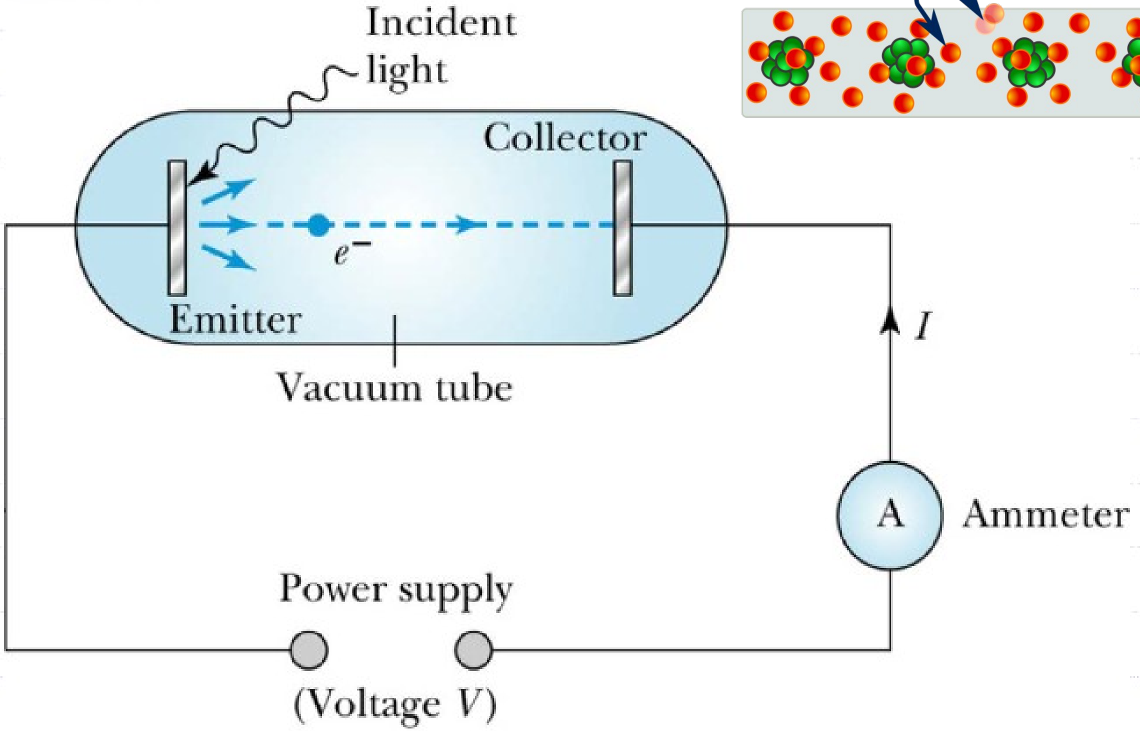


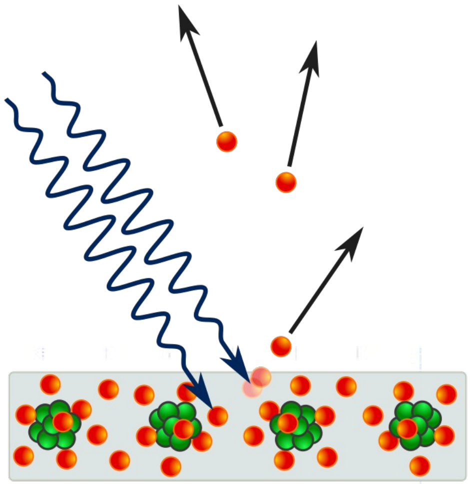

Fossile radiation of the Big Bang
T = 2.735 ± 0.06 K
Error barre...!
(mesured in 9 minutes !)
Brightness (10^{-9} W m^{-2} sr^{-1})
Frequency (× 3 × 10^{10} Hz)
0
20
40
60
80
100
120
1
2
4
6
8
10
12
14
16
18
20

The **photoelectric effect** is the emission of electrons when electromagnetic radiation, such as light, hits a material. Electrons emitted in this manner are called photoelectrons.

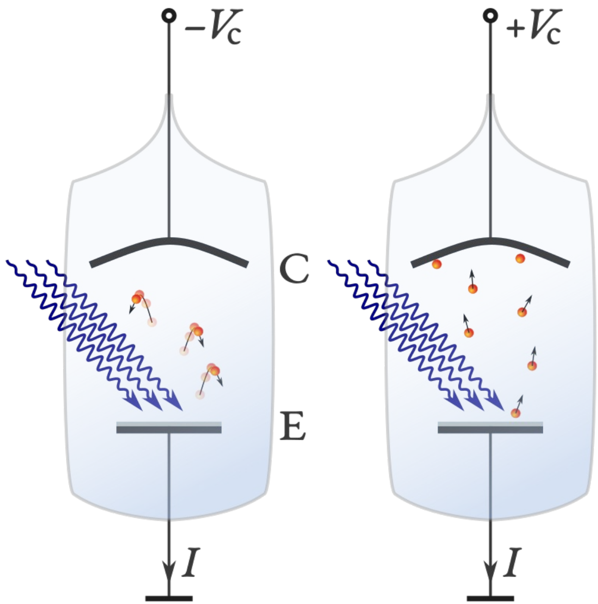
Light incident on a metal with sufficient energy will eject electrons

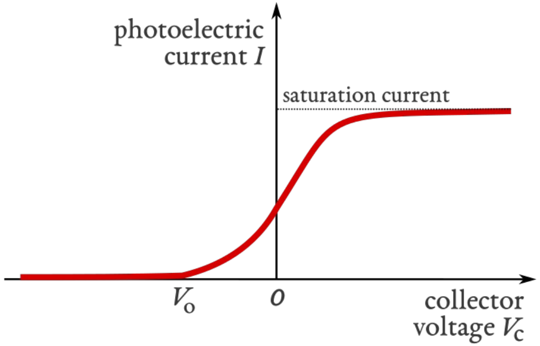




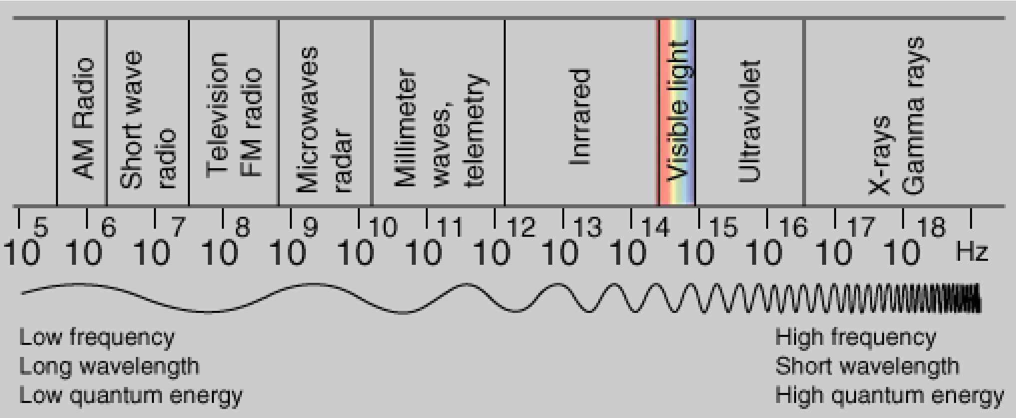


$$E_k = \frac{1}{2}mv^2 = h\nu - W = \frac{hc}{\lambda} - W$$



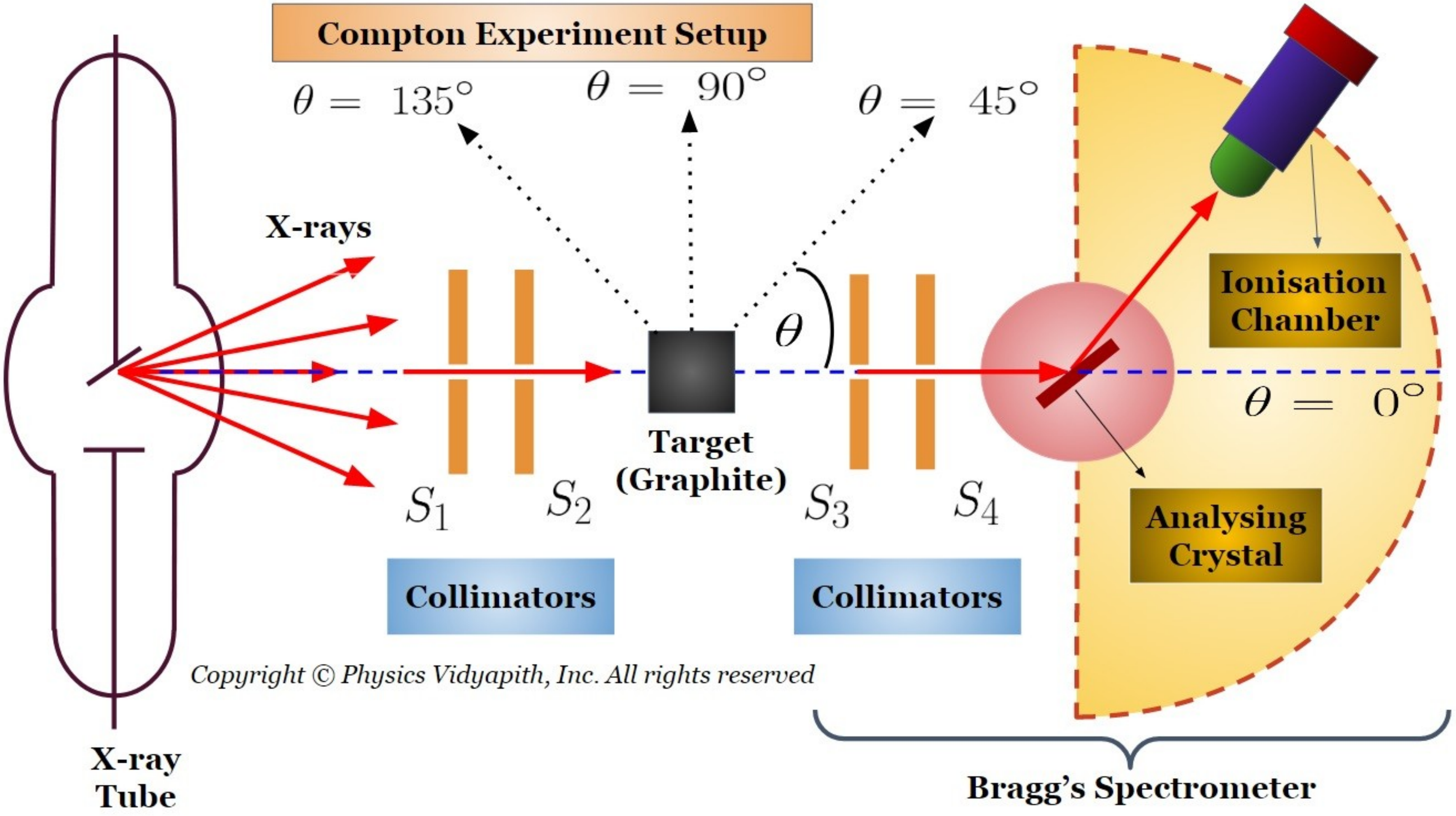


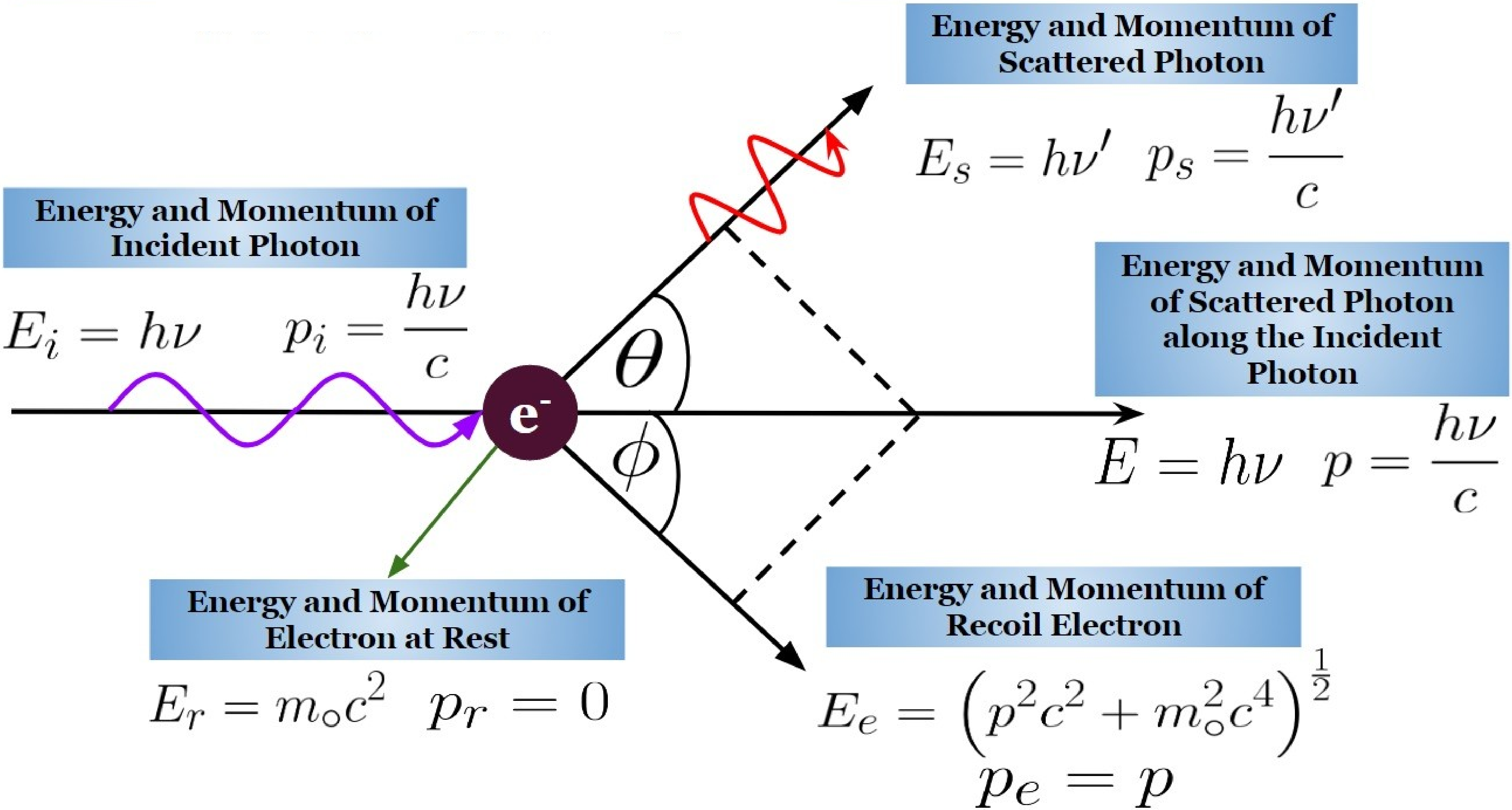
METAL	WORKFUNCTION (eV)	METAL	WORKFUNCTION (eV)
Al	4.3	Ru	4.7
Ti	4.33	Rh	4.98
V	4.3	Hf	3.9
Cr	4.5	Ta	4.25
Mn	4.1	W	4.55
Fe	4.7	Re	4.96
Co	5	Os	4.83
Ni	5.15	Ir	5.27
Nb	4.3	Au	5.1
Mo	4.6	TaN/TaSiN	3.9-4.3



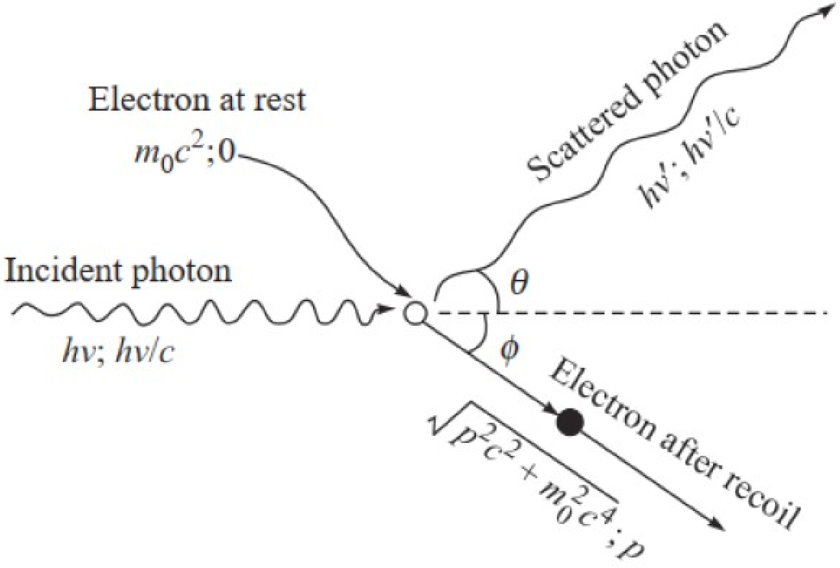
Compton effect :

An increase in wavelength of X-rays or gamma rays that occurs when they are scattered (discovered in 1923 by Arthur Holly Compton)

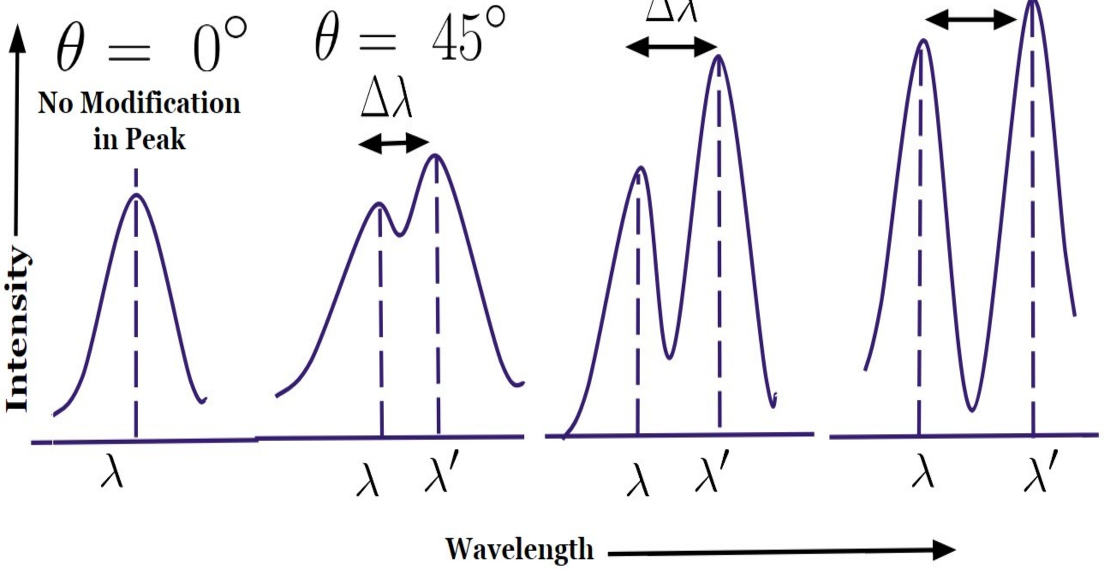




Energy and Momentum of Scattered Photon
$E_s = h\nu' \quad p_s = \frac{h\nu'}{c}$
Energy and Momentum of Incident Photon
$E_i = h\nu \quad p_i = \frac{h\nu}{c}$
e-
θ
ϕ
Energy and Momentum of Scattered Photon along the Incident Photon
$E = h\nu \quad p = \frac{h\nu}{c}$
Energy and Momentum of Electron at Rest
$E_r = m_\circ c^2 \quad p_r = 0$
Energy and Momentum of Recoil Electron
$E_e = \left(p^2c^2 + m_\circ^2 c^4\right)^{\frac{1}{2}}$
$p_e = p$



$$\Delta\lambda = \frac{2h}{m_0 c}\sin^2\frac{\theta}{2}$$

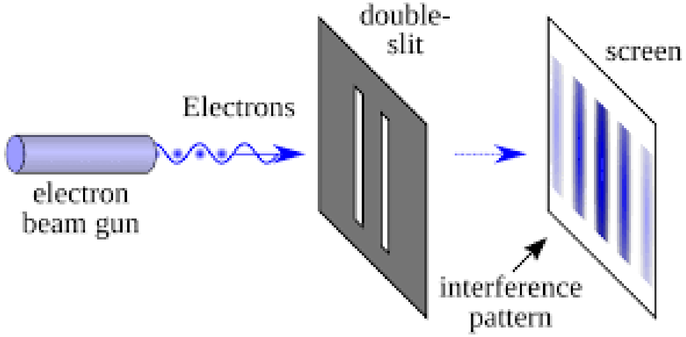


The dual nature of matter

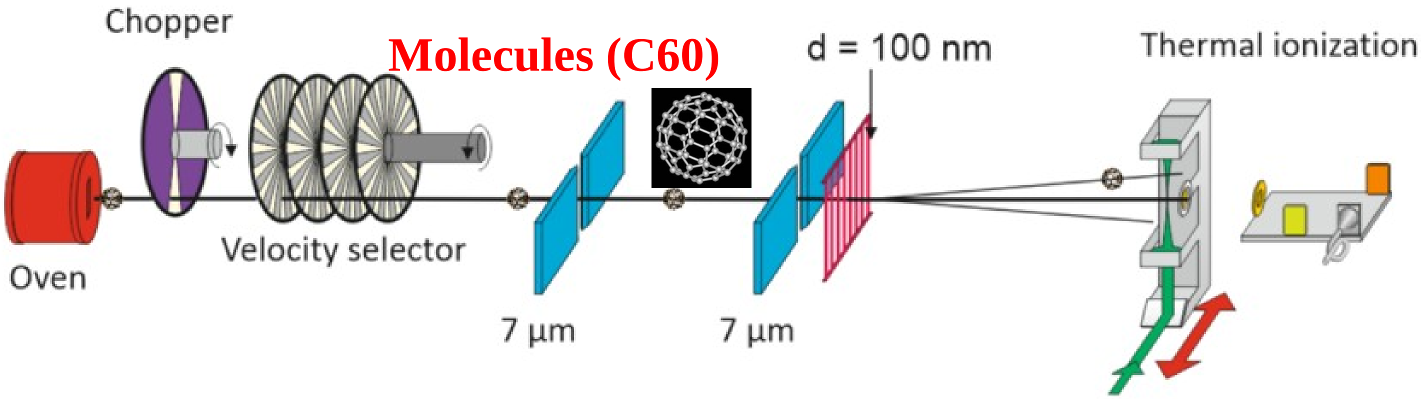
De Broglie proposed that as light exhibits both wave-like and particle-like properties, matter exhibits wave-like and particle-like properties. This nature was described as dual behaviour of matter. On the basis of his observations, de Broglie derived a relationship between wavelength and momentum of matter.

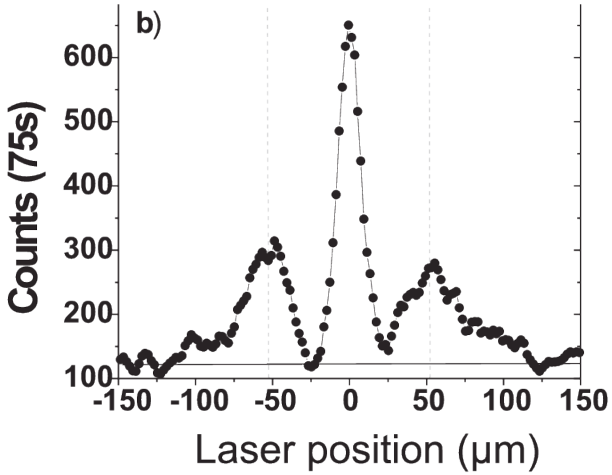
$$\lambda = \frac{h}{p}$$

Electrons



Molecules (C60)





M. Arndt, O. Nairz, J. Vos-Andreae, C. Keller, G. van der Zouw, A. Zeilinger, *Wave-particle duality of C_{60} molecules.*, **Nature 401, 680-682 (1999)**