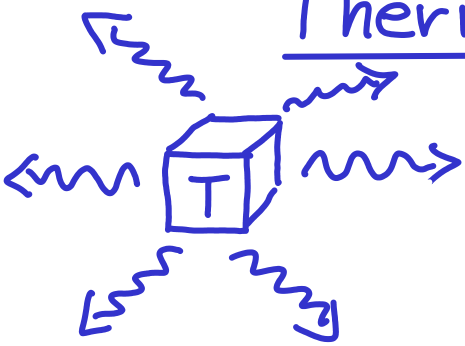
Thermal radiation



radio- and microwave, mostly infrared, can be visible or ultraviolet

Stefan-Boltzmann law: $\boxed{P = \sigma \varepsilon A T^4}$

T: absolute temperature in kelvin

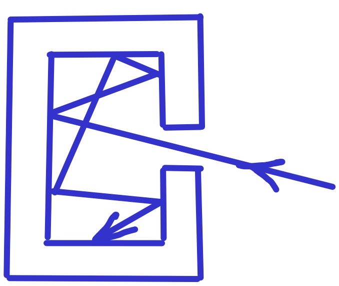
A: surface area of the object

ε or e: emissivity $0 \le \varepsilon \le 1$

σ: Stefan-Boltzmann constant:

$$5.6703 \cdot 10^{-8} \frac{W}{m^2 K^4}$$

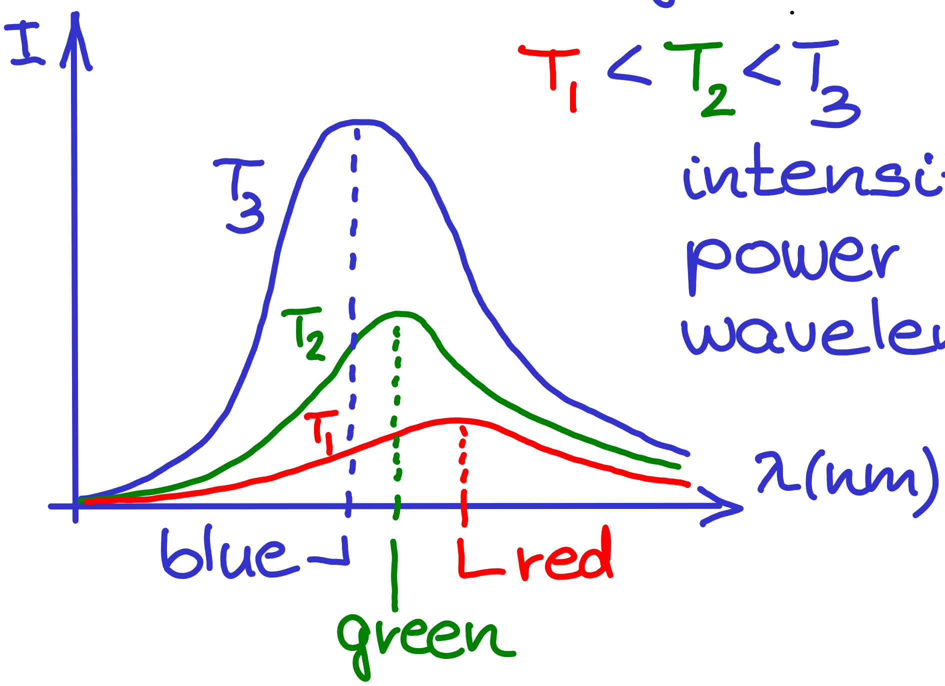
Black-body: a=1 absorbs everything
e=1 emits the most



heated cavity (= oven)

The hole on the cavity behaves like a black-body: it absorbs all the radiation landing on it.

Blackbody radiation



$I = I(\lambda, T)$: intensity distribution: power per area per wavelength

$$[I] = \frac{W}{m^2} \cdot \frac{1}{m}$$

Wien's displacement law (1911 Nobel)

$$\boxed{\lambda_{max} \cdot T = b \; ; \quad b = 2.898 \cdot 10^{-3} \ m \cdot K}$$

Sun: $\lambda_{max} = 550\,nm \Rightarrow T = 5800\,K$

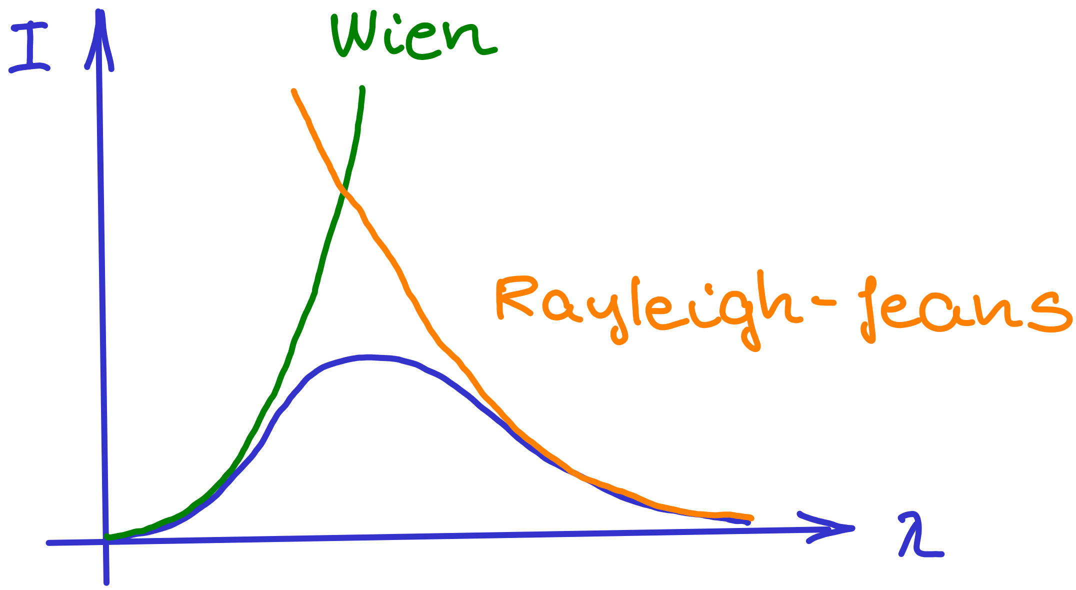
Stefan-Boltzmann law:

$$\boxed{P = \sigma \varepsilon A T^4 \; ; \quad \sigma = 5.6705 \cdot 10^{-8} \ \frac{W}{m^2 K^4}}$$

P: total area under the intensity distribution curve.

Max Planck (1918 Nobel): the exact shape of the intensity distribution curve. (You will learn about it in Quantum Mechanics.)

Problems

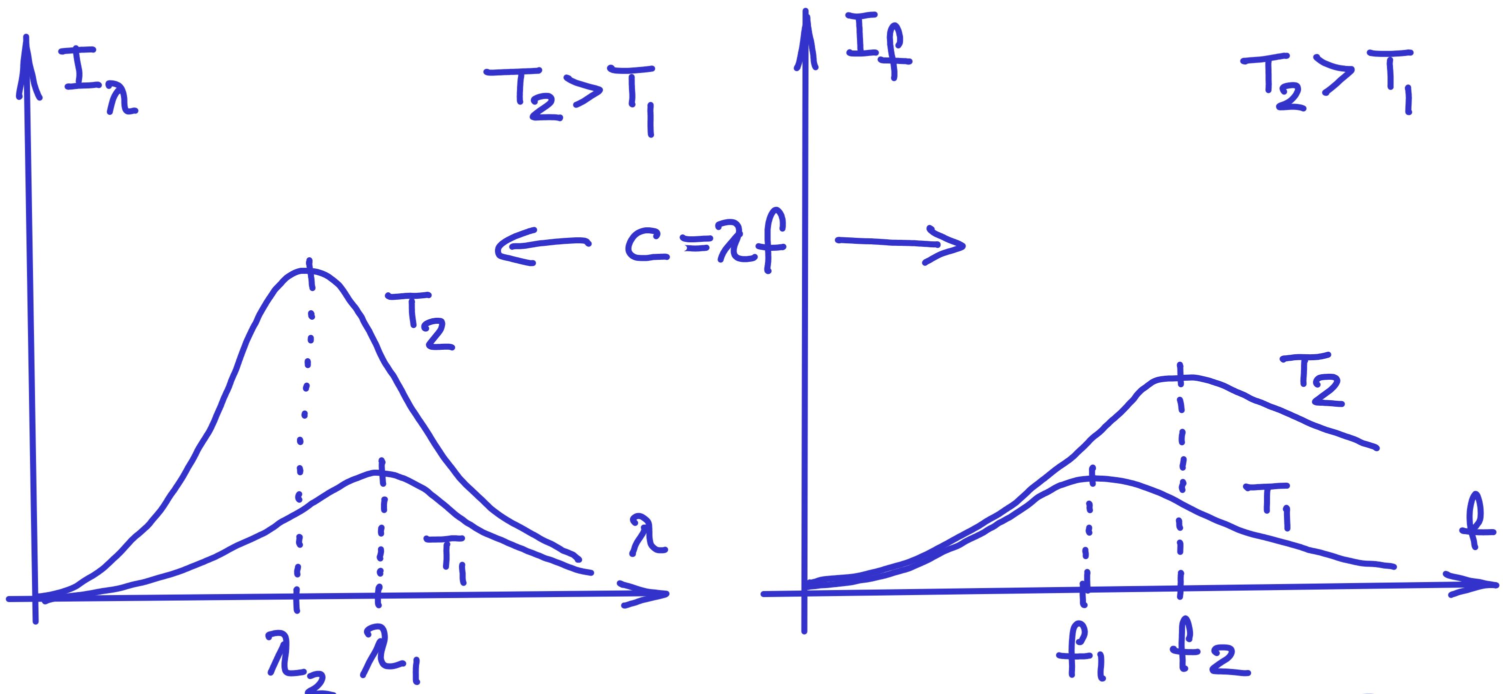


Wien : infrared catastrophe

Rayleigh-Jeans : ultraviolet catastrophe

Max Planck

(1918 Nobel Prize)



$$I_\lambda = \frac{2\pi c^2 h}{\lambda^5} \cdot \frac{1}{e^{\frac{hc}{\lambda k_B T}} - 1} \; ; \quad I_f = \frac{2\pi h}{c^2} \cdot \frac{f^3}{e^{\frac{hf}{k_B T}} - 1}$$

Key assumption:

$$\Delta E = hf$$

$$E_n = nhf \; ; \quad n = 0, 1, 2, 3, \ldots$$

$$\boxed{h = 6.6261 \cdot 10^{-34} \text{ Js}}$$

Planck's constant