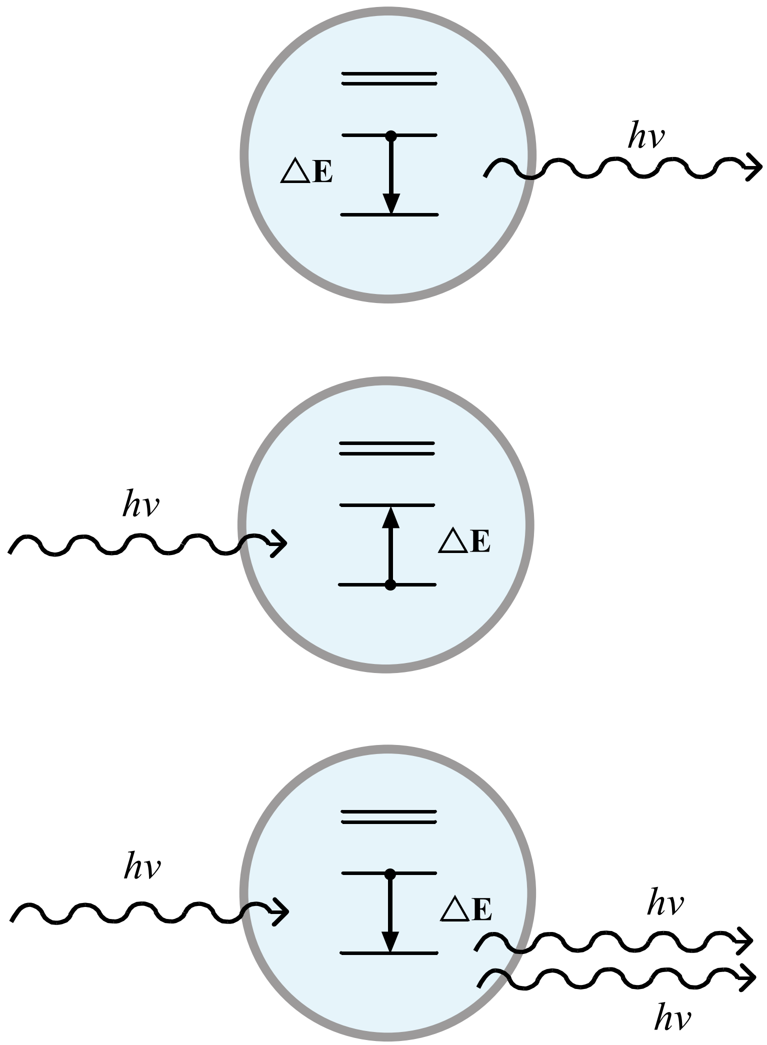
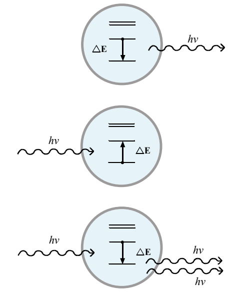
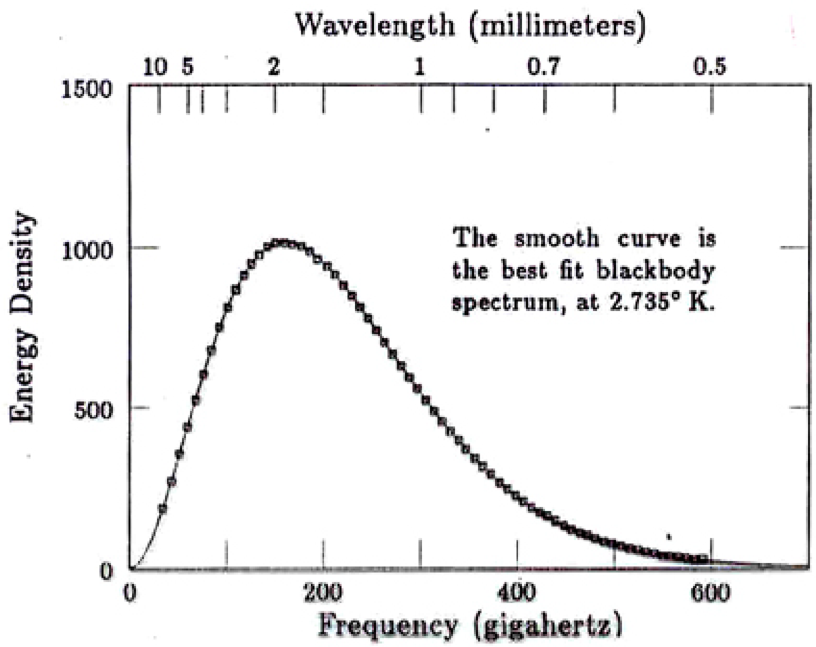


Nelson Zamorano Hole

Física Contemporánea

FCFM UNIVERSIDAD DE CHILE




Wavelength (millimeters)
10 5 2 1 0.7 0.5
1500
1000
500
0
Energy Density
The smooth curve is the best fit blackbody spectrum, at 2.735° K.
0 200 400 600
Frequency (gigahertz)

RADIACIÓN de CUERPO NEGRO

— UNIVERSAL

- indep. de la naturaleza del cuerpo

El flujo de calor depende del GRAD. de T.

- indep. de la Geometría ...
- Equil. Termodinámico
- ec. de Maxwell

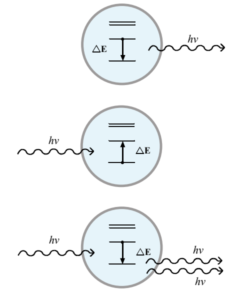
Idea y Aporte de Plank

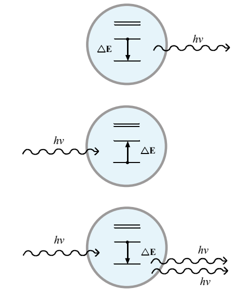
CRISIS:

Onda E-M en una cavidad (microondas)

1 Dim

$n = 1, 2, 3, \ldots$ • modos de oscilación
• son indep. entre sí.





• Eq. Termod. ⇒

c/modo necesita (kT)

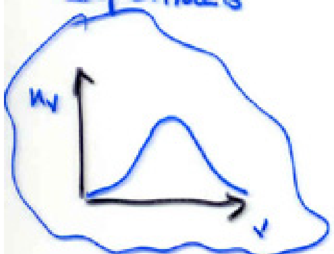
Pre-Plank !!

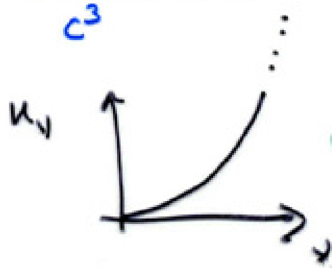
Problema con esta teoría:

\# de modos $\propto \nu^2$

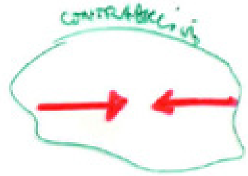
$$u_\nu(T) \equiv \frac{\text{Energía}}{\text{u. de vol.}} \cdot \frac{1}{\Delta\nu \text{ de frecuencia}} = \frac{8\pi\nu^2}{c^3} \cdot kT$$

Experimento

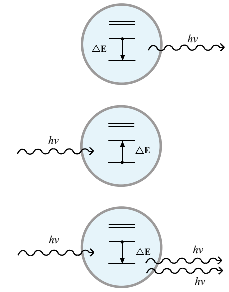




contradicción

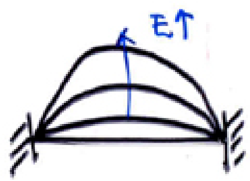


$\nu \uparrow$ ⇒ En. necesaria crece sin límite



Hipótesis ad-hoc de Planck

TRADICIÓN



En c/modo la Energía puede cambiar en forma continua

Planck: La energía aumenta a saltos prop. a la frecuencia

MATEMÁTICA

$\Rightarrow \int \to \Sigma$

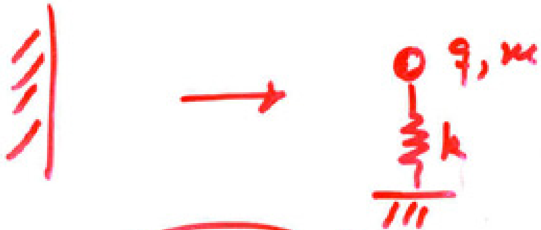
$$E = n\hbar\omega = nh\nu$$

$n = 1, 2, 3, \ldots$

$$\Rightarrow \langle E \rangle = \frac{h\nu}{e^{\frac{h\nu}{kT}} - 1}$$

$$u_T(\nu) = \frac{8\pi\nu^2}{c^3} \cdot \frac{h\nu}{e^{\frac{h\nu}{kT}} - 1}$$

Funciona!!



PARED

Onda E-M

RADIACCIÓN

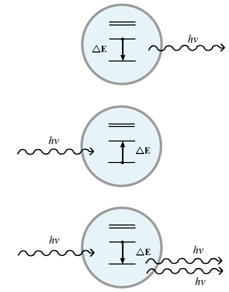
$\Downarrow$

Maxwell

$$\langle \varepsilon \rangle = \frac{\int_0^\infty \varepsilon\, e^{-\beta\varepsilon}\, d\varepsilon}{\int_0^\infty e^{-\beta\varepsilon}\, d\varepsilon} = kT$$

Fís. Estadística

$$\nabla^2 \vec{E} - \frac{1}{c^2}\frac{\partial^2 \vec{E}}{\partial t^2} = 0 \qquad \text{(Maxwell)}$$



Sol.

$$E_x = E_{0x} \cos n_1 \frac{\pi x}{L} \cdot \operatorname{sen} \frac{n_2 \pi y}{L} \cdot \operatorname{sen} n_3 \frac{\pi z}{L} \cdot$$

$$\cdot \operatorname{sen} 2\pi \nu t \,.$$

$E_y = \ldots$

$E_z = \ldots$

$$n_1^2 + n_2^2 + n_3^2 = \left(\frac{2L}{c}\nu\right)^2$$

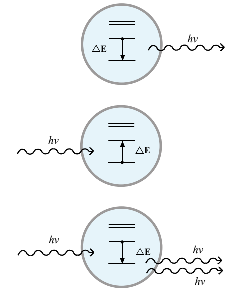
de modos entre ν y $(\nu + d\nu)$

$$dN = \frac{dN}{d\nu} d\nu = \frac{1}{8} 4\pi n^2 dn = \frac{\pi}{2} \frac{4L^2\nu^2}{c^2} \cdot \frac{dn}{d\nu} d\nu$$

$$\downarrow$$

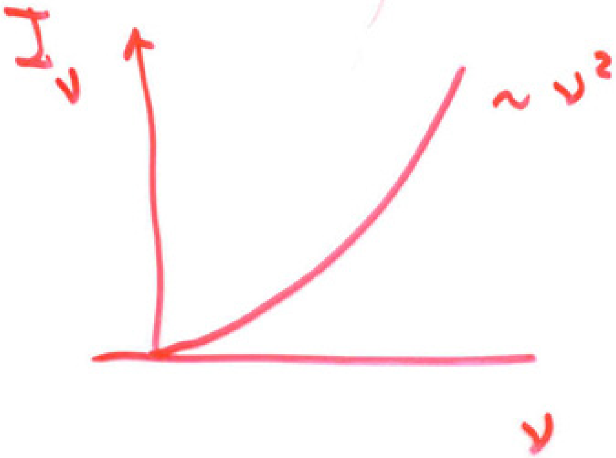
$$N_\nu \, d\nu = 4\pi \frac{L^3 \nu^2}{c^3} d\nu$$

$$\overset{n_\nu}{\cancel{N_\nu}} = \frac{8\pi\nu^2}{c^3} \cdot V \qquad n_\nu = \frac{8\pi\nu^2}{c^3}$$



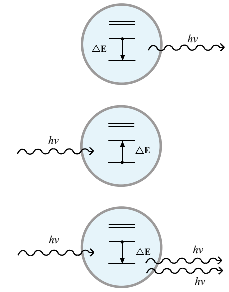
$$u_\nu(T)\,d\nu = \frac{8\pi\nu^2}{c^3}\cdot\langle\varepsilon\rangle\cdot d\nu$$

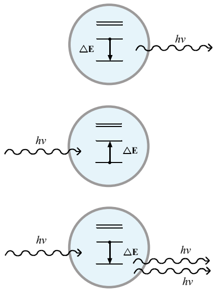
$$= \frac{8\pi\nu^2}{c^3}\,kT\,d\nu$$



PLANCK

$$\langle\varepsilon\rangle = \frac{\sum_{n=1}^{\infty} \varepsilon_n e^{-\beta\varepsilon_n}}{\sum_{n=1}^{\infty} e^{-\beta\varepsilon_n}}$$





$$\langle \varepsilon \rangle = \frac{h\nu}{e^{\beta h\nu}-1}$$

$$u_\nu(T)\,d\nu = \frac{8\pi\nu^2 d\nu}{c^3}\cdot\frac{h\nu}{e^{\beta\nu h}-1}$$