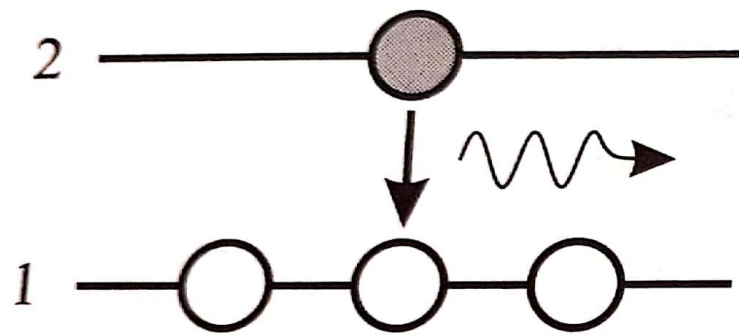


# LASER

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# Interactions lumière matière

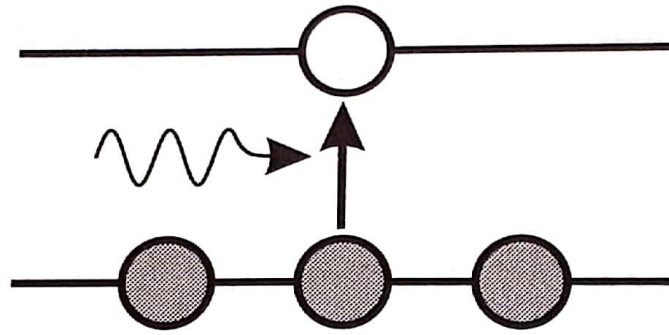
Photon incident:  $E = \hbar\omega_0$



(a) émission spontanée

$$p_{es} = A_{21}$$

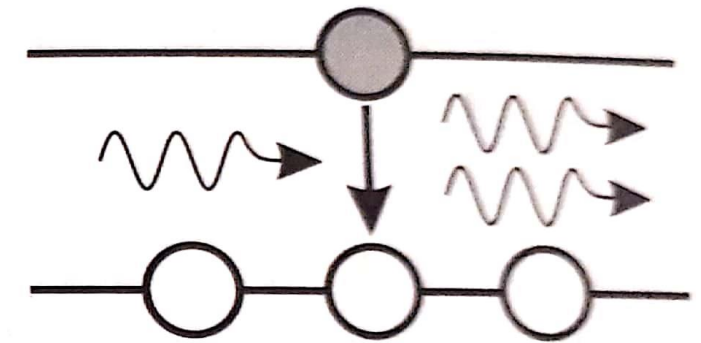
$$\frac{dN_2}{dt}_{abs} = -A_{21} * N_2$$



(b) absorption

$$p_{abs} = B_{12} * w(\omega_0)$$

$$\frac{dN_1}{dt}_{abs} = -B_{12} * w(\omega_0) * N_1$$



(c) émission stimulée

$$p_{ei} = B_{21} * w(\omega_0)$$

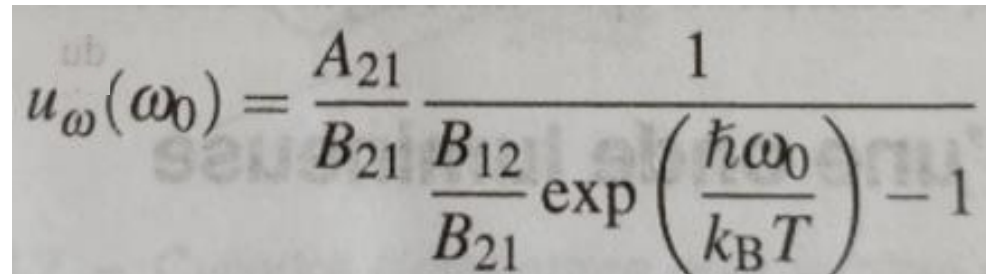
$$\frac{dN_2}{dt}_{abs} = -B_{21} * w(\omega_0) * N_2$$

# Loi de stéphane Boltzman

Densité volumique d'énergie spectrale  
selon la loi de Planck

$$u_{\omega} = \frac{\hbar}{c^3 \pi^2} \frac{\omega^3}{\exp\left(\frac{\hbar\omega}{k_B T}\right) - 1}$$

Densité volumique d'énergie spectrale  
trouvé

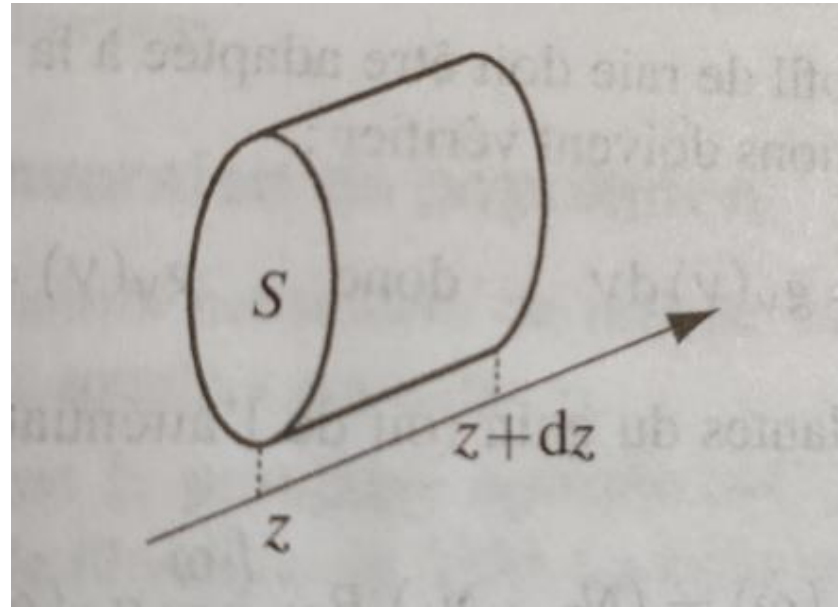


A photograph of a handwritten formula on a piece of paper. The formula is for the spectral energy density  $u_{\omega}(\omega_0)$  and is written as  $u_{\omega}(\omega_0) = \frac{A_{21}}{B_{21}} \frac{1}{\frac{B_{12}}{B_{21}} \exp\left(\frac{\hbar\omega_0}{k_B T}\right) - 1}$ . The handwriting is in black ink on a light-colored background.

$$u_{\omega}(\omega_0) = \frac{A_{21}}{B_{21}} \frac{1}{\frac{B_{12}}{B_{21}} \exp\left(\frac{\hbar\omega_0}{k_B T}\right) - 1}$$

# Bilan de puissance dans un volume du milieu

Volume éclairée  
par une intensité lumineuse  $I$



$$\underbrace{S * dz * dw(z, t + dt) - S * dz * dw(z, t)}_{\text{Variation d'énergie entre } t \text{ et } t+dt} = \underbrace{S * I(z, t)dt - S * I(z + dz, t)dt}_{\text{Energie entrante - énergie sortante}} + \underbrace{(\pi_{emise} - \pi_{abs} - \pi_{perte})S * dt}_{\text{Variation d'énergie du au milieu et aux pertes}}$$

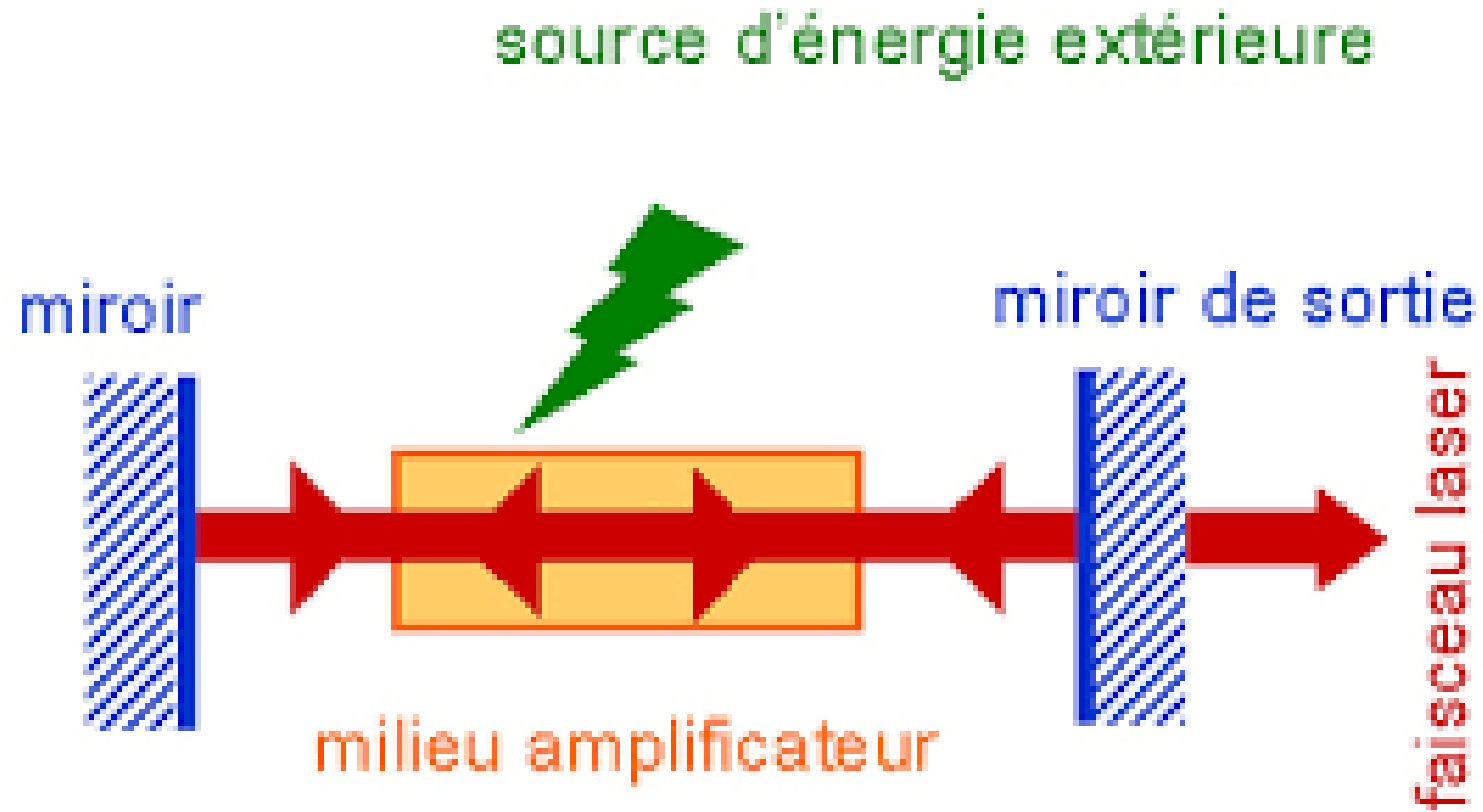
Variation d'énergie entre  $t$  et  $t+dt$

Energie entrante – énergie sortante

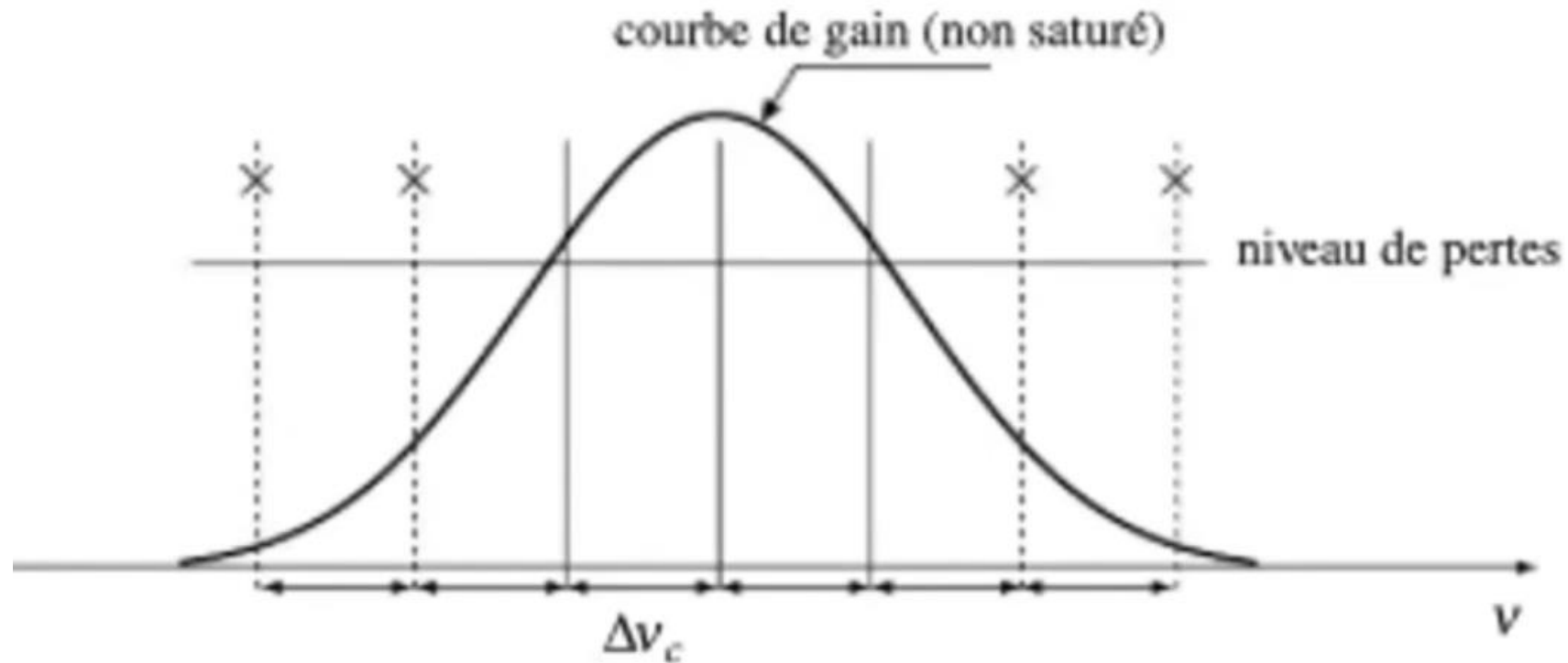
Variation d'énergie du au milieu  
et aux pertes

$$\frac{\partial I}{\partial z} + \frac{\partial w}{\partial t} = \pi_{emis} - \pi_{abs} - \pi_{perte}$$

# Principe du laser



# Coube de gain et niveau des pertes



# Faisceau gaussien

$$\underline{s}(r, z, t) = \underline{a}(r, z) e^{i\omega t}$$

$$\underline{a}(r, z) = \underbrace{\underline{a}_0 \frac{w_0}{w(z)} \exp\left(-\frac{r^2}{w(z)^2}\right)}_{\text{amplitude}} \underbrace{\exp\left(-ikz - ik\frac{r^2}{2R(z)} - i\phi(z)\right)}_{\text{phase}}$$

$$w(z) = w_0 \sqrt{1 + \left(\frac{z}{z_R}\right)^2}, \quad R(z) = z + \frac{z_R^2}{z} \quad \text{et} \quad \phi(z) = -\arctan\left(\frac{z}{z_R}\right) \quad \text{où} \quad z_R = \frac{\pi w_0^2}{\lambda}.$$