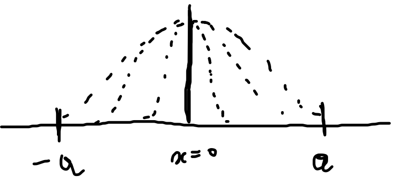


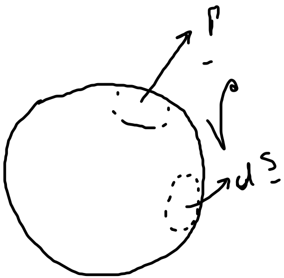
$\Delta x \qquad \Delta t$

$\langle x \rangle = 0$

$\langle x^2 \rangle \neq 0$

$$\langle x^2 \rangle = N (\Delta x)^2 = t \frac{(\Delta x)^2}{\Delta t}$$

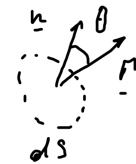
$$N = \frac{t}{\Delta t} \qquad \sigma = \sqrt{\langle x^2 \rangle} \propto \sqrt{t}$$



$\underline{\Gamma}$: flusso netto di particelle che entrano/escono dal volume V

$[\Gamma]$: $\dfrac{\text{particelle}}{m^2 \cdot s}$

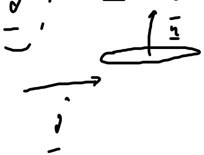
$\underline{\Gamma} \cdot d\underline{S} = \Gamma\, dS \cos\theta$



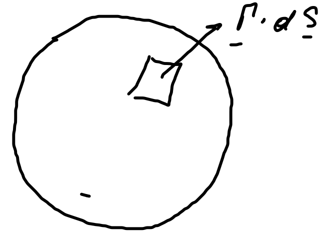
Se $\underline{\Gamma} \cdot d\underline{S} > 0$: particelle escono da dS

Se $\underline{\Gamma} \cdot d\underline{S} < 0$: " entrano in dS

Fisica 2: $\underline{j}$: $I = \underline{j} \cdot d\underline{S}$



$$\frac{dN}{dt} = -\int_{Sup} \underline{\Gamma}\cdot d\underline{S}$$



$\underline{\Gamma}\cdot d\underline{S} < 0$ se part. entrano $\Rightarrow \frac{dN}{dt} > 0 \Rightarrow$ segno $-$

$$\int_{Sup} \underline{\Gamma}\cdot d\underline{S} = \int_V (\underline{\nabla}\cdot\underline{\Gamma})\, dV \qquad N = \int_V n\, dV$$

n densità di particelle (part/m^3)

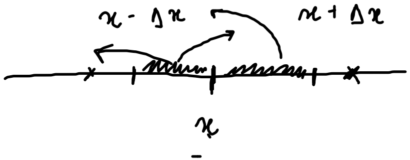
$$\frac{d}{dt}\int_V n\, dV = -\int_V (\underline{\nabla}\cdot\underline{\Gamma})\, dV$$

$$\int_V \frac{\partial n}{\partial t}\, dV = -\int_V (\underline{\nabla}\cdot\underline{\Gamma})\, dV$$

$$\int_V \left(\frac{\partial n}{\partial t} + \underline{\nabla}\cdot\underline{\Gamma}\right) dV = 0 \quad \Rightarrow \quad \frac{\partial n}{\partial t} + \underline{\nabla}\cdot\underline{\Gamma} = 0$$

V arbitrario

Modello 1D per $\underline{\Gamma}$



Quante $\dfrac{\text{particelle}}{m^2 \cdot s}$ attraversano x?

$$\Gamma(x,t) = \overbrace{\left[\frac{\text{part.}}{m^2} \text{ che a } t-\Delta t \text{ si trovavano in } (x, x-\Delta x)\right]}^{\Gamma_+(x,t) \;>0} - \underbrace{\left[\frac{\text{part.}}{m^2} \text{ che a } t-\Delta t \text{ si trovavano in } (x, x+\Delta x)\right]}_{\Gamma_-(x,t)}$$

$$\Gamma(x,t) = \Gamma_+(x,t) - \Gamma_-(x,t) = \frac{1}{2\Delta t}\int_{x-\Delta x}^{x} n(x')\,dx' - \frac{1}{2}\frac{1}{\Delta t}\int_{x}^{x+\Delta x} n(x')\,dx'$$

$n\,dV = \#$ particelle $\qquad dV = S \cdot dx$

$$\# \frac{\text{part}}{m^2} = \frac{n\,dV}{S} = n\,dx$$

$$\Gamma_{+}(x) = \frac{1}{2\Delta t}\int_{x-\Delta x}^{x} n(x')\,dx' =$$

$$f(x) \simeq f(x_0) + \left.\frac{df}{dx}\right|_{x=x_0}(x-x_0)$$

$$\Delta x \ll L \quad : \quad n(x') \simeq n(x) + \left.\frac{dn}{dx'}\right|_{x}(x'-x)$$

$$= \frac{1}{2\Delta t}\int_{x-\Delta x}^{x}\left[n(x) + \left.\frac{dn}{dx'}\right|_{x}(x'-x)\right]dx' =$$

$$= \frac{1}{2\Delta t}\left[n(x)\int_{x-\Delta x}^{x}dx' + \left.\frac{dn}{dx'}\right|_{x'=x}\int_{x-\Delta x}^{x}(x'-x)\,dx'\right]$$

$$= \frac{1}{2\Delta t}\left[n(x)\left[x-x+\Delta x\right] + \left.\frac{dn}{dx'}\right|_{x'=x}\frac{1}{2}(x'-x)^2\Big|_{x-\Delta x}^{x}\right] =$$

$$= \frac{1}{2\Delta t}\left[n(x)\,\Delta x - \frac{1}{2}(\Delta x)^2\left.\frac{dn}{dx'}\right|_{x'=x}\right]$$

$$\Gamma_-(x) = \frac{1}{2\Delta t}\left[n(x)\int_x^{x+\Delta x} dx' + \left.\frac{dn}{dx'}\right|_{x'=x} \int_x^{x+\Delta x} (x'-x)\, dx \right]$$

$$= \frac{1}{2\Delta t}\left[n(x)\Delta x + \left.\frac{dn}{dx'}\right|_{x'=x} \left.\frac{1}{2}(x'-x)^2\right|_x^{x+\Delta x} \right]$$

$$= \frac{1}{2\Delta t}\left[n(x)\,\Delta x + \left.\frac{dn}{dx'}\right|_{x'=x} \frac{(\Delta x)^2}{2} \right]$$

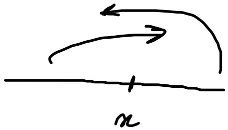
$$\Gamma_+(x) = \frac{1}{2\Delta t}\left[n(x)\,\Delta x - \left.\frac{dn}{dx'}\right|_{x'=x} \frac{(\Delta x)^2}{2} \right]$$

$$\Gamma = \Gamma_+ - \Gamma_- = -\frac{1}{2\Delta t}\frac{dn}{dx}(\Delta x)^2 = -D\frac{dn}{dx}$$

D = coefficiente di diffusione

$$= \frac{(\Delta x)^2}{2\Delta t}$$

$$\frac{\partial n}{\partial t} + \underbrace{\frac{d}{dx}\Gamma}_{\underline{\nabla}\cdot\underline{\Gamma}} = 0$$



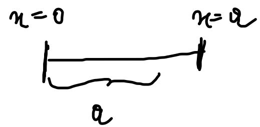
$$\frac{\partial n}{\partial t} = -\frac{d\Gamma}{dx} = +\frac{d}{dx}\left(D\frac{dn}{dx}\right)$$

$$\Gamma = -D\frac{dn}{dx}$$

$$\Gamma = -D\frac{dn}{dx}$$

Flusso netto solo se $\frac{dn}{dx} \neq 0$

Flusso solo se c'è sbilanciamento tra particelle a DX e SX $\Rightarrow \frac{dn}{dx} \neq 0$



n non è una costante

$$\frac{\partial n}{\partial t} = \underline{\nabla}\cdot\left(D\underline{\nabla} n\right) \qquad \frac{\cancel{n}}{\tau} \approx \frac{D}{a^2}\cancel{n} \; ; \qquad \tau \approx \frac{a^2}{D}$$

Se $D \neq 0$, allora $\tau \neq 0$

Se $D \to 0$, allora $\tau \to +\infty$

τ : tempo confinamento delle particelle

$$\tau_E \approx \frac{r^2}{\chi}$$

$\chi \rightarrow$ coefficiente di diffusione energia

$$[\chi] = [D] = m^2/s$$

$$d + t \rightarrow \alpha + n$$

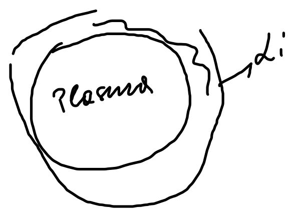
$E_n \approx 14$ MeV

$E_\alpha \approx 3.5$ MeV

$T_\alpha \approx T_t \approx 10-20$ keV

$$\tau_\alpha > \tau_{SL}$$

slowing down



$n + {}^6Li$

$n + {}^7Li$

(t)

Caso $B = 0$

$$D \sim \frac{(\Delta x)^2}{\Delta t}$$

freq. collisionale

$\nu = (\Delta t)^{-1}$

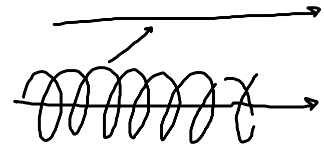
$\Delta x \sim \lambda_{mfp}$ (libero cammino medio)

$$\lambda_{mfp} \approx v_{th} \cdot \Delta t \sim v_{th} \nu^{-1}$$

$$D \sim v_{th}^2 \nu^{-2} \cdot \nu \sim v_{th}^2 \nu^{-1} \sim \frac{T}{m\nu}$$

Caso $B \neq 0$

$$\Delta x \sim r_L$$



$$D \sim \frac{(\Delta x)^2}{\Delta t} \sim r_L^2 \nu$$

$$D \propto \nu$$