Zeroth order moment

$$\int \frac{\partial f}{\partial t} d^3\bar{v} + \int \bar{v}\cdot\frac{\partial f}{\partial \bar{x}} d^3 v$$

$$+ \frac{q}{m}\int (\bar{E}+\bar{v}\times\bar{B})\frac{\partial f}{\partial \bar{v}} d^3\bar{v} = \int \left(\frac{\partial f}{\partial t}\right)_c d^3\bar{v}$$

First term

$$\int \frac{\partial f}{\partial t} d^3 v = \frac{\partial}{\partial t}\int f d^3\bar{v} = \frac{\partial n}{\partial t}$$

$$\int v\cdot\frac{\partial f}{\partial x} d^3\bar{v}) = \frac{1}{\partial \bar{x}}\int \bar{v} d^3\bar{v} = \frac{\partial}{\partial \bar{x}}(n\bar{v}) = \frac{\partial}{\partial \bar{x}} n\bar{v}$$

$$\int (E\cdot\frac{\partial f}{\partial v} d^3 v) = \int \frac{\partial}{\partial \bar{v}}(f\bar{E}) d^3 v = \int_S f\bar{E}\cdot dS_v = 0$$

Gauss' law

Vanishes as we take $S \to \infty$

$S \xrightarrow{\text{incr}} v^2$ but $f(\bar{v})$ the distribut

will go to zero $\exp(-v^2/v_T^2)$

$$\int (\bar{v}\times\bar{B})\cdot\frac{\partial f}{\partial \bar{v}} d^3\bar{v} = \int \frac{\partial}{\partial v}(f(\bar{v}\times\bar{B})) d^3\bar{v}$$

$$-\int f\,\frac{\partial}{\partial \bar{v}}\cdot(\bar{v}\times\bar{B}) d^3\bar{v} = 0$$

first term as surface integra

Second term $\bar{v}\times\bar{B} \perp \partial/\partial\bar{v}$

Collision term also goes to zero since number of particles of specie remain constant.

$$\frac{\partial n}{\partial t} + \frac{\partial}{\partial \bar{x}}(n\bar{u}) = 0.$$

Conservation of particles.

second order. multiply by $m\bar{v}$

$$m\int \bar{v}\frac{\partial f}{\partial t}\,d^3\bar{v} + m\int \bar{v}\left(\bar{v}\cdot\frac{\partial}{\partial x}\right) f\,d^3\bar{v}$$
$$+ q\int \bar{v}\left(\bar{E} + \bar{v}\times\bar{B}\right)\frac{\partial f}{\partial \bar{v}}\,d^3\bar{v}$$
$$= \int m v\left(\frac{\partial f}{\partial t}\right)d^3\bar{v}$$

Ther first term gives

$$m\int v\,\frac{\partial f}{\partial t}\,d^3v = m\frac{\partial}{\partial t}\int v\,.\,d^3v = m\frac{\partial\, n\bar{u}}{\partial t}$$

$$-q\int \bar{E} + \bar{v}\times\bar{B}\; f\,d^3v = -qn\left(\bar{E} + \bar{v}\times\bar{B}\right.$$

second term.

$$\frac{\partial}{\partial x}\cdot\left(n\,\overline{\bar{v}\bar{v}}\right)$$

$$\mu = \frac{F}{A} \Big/ \frac{\Delta v_x}{\Delta z}$$

from momentum eq^n

assume const density & pressure

& ignore any external forces.

$$\frac{\partial}{\partial t}(\rho\, u_x) = \underbrace{\frac{\partial}{\partial y}\, \mu \frac{\partial u_x}{\partial y}}$$

Viscous force per unit volume acting on fluid element

- The rate at which particles cross upper surface

$$\sim \frac{n v_T}{2} \Delta A \qquad v_T \simeq \left(\frac{KT}{m}\right)^{1/2}$$

- The particles travel distance λ before colliding & exchanging momentum, so even though equal number of particles cross the boundary in upward & downward. there is systematic difference in momentum

$$\Delta p_x \sim 2m\lambda \frac{\partial u_x}{\partial y} \quad \text{per particle.}$$

- The rate of change of the element momentum at boundaries.

$$\frac{dp_x}{dt} \sim \left[m\lambda \frac{\partial u_x}{\partial y}\, n v_T\, \Delta A\right]_{@\, y+\Delta y} - \left[m\lambda \frac{\partial u_x}{\partial y}\, n v_T\, \Delta A\right]_{@\, y}$$

we must substract momentum taken oult by particles crossing the botton Surface

Dividing $\Delta A \, \Delta y$ the volum.

force per unit volum

$$\frac{\partial}{\partial y}\left(\mu \frac{\partial u_x}{\partial y}\right) \sim \frac{\partial}{\partial y}\left(n m \lambda v_T \frac{\partial u_x}{\partial y}\right)$$

using

$$\lambda = \frac{1}{n\sigma}$$

$$\mu \simeq \frac{m v_T}{\sigma}$$

$$\eta = \frac{1}{3\sqrt{2}} \frac{m}{\sigma_0} \bar{v}$$

$$\bar{v} = \sqrt{\frac{8}{\pi} \frac{k_B T}{m}}$$

η = depends only on T not on the densiy or pressure.

Heat Conduction

$$\vec{Q} = -K \vec{\nabla} T$$

$$Q_z = -k \frac{\partial T}{\partial z}$$

$$K = \frac{1}{3} n \bar{v} c \lambda$$

$$c = \frac{\partial \bar{\epsilon}}{\partial T}$$ Specific energy per molecule

$$K = \frac{1}{3\sqrt{2}} \frac{c}{\sigma_0} \bar{v}$$ indepen of P

$$\frac{k}{\eta} = \frac{c}{m}$$

Diffusion

due to density gradient it arise

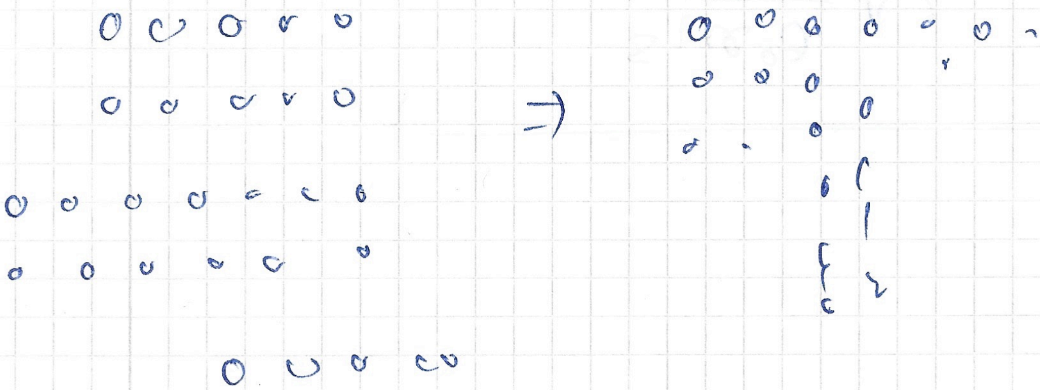
$$j_z = -D \frac{\partial n}{\partial z}$$

$$D = \frac{1}{3} \bar{v} \lambda$$

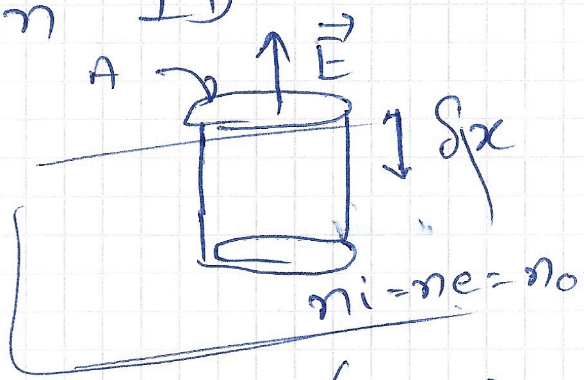
$$\frac{D}{\eta} = \frac{1}{nm}$$

Plasma Osci^n

$$n_{0_i} \approx n_{0_e} = n_0$$



Consider small perturbation of eletric charge in 1D



$$Q = -e n_0 (A \delta x)$$

$$\oint \bar{E}_1 \cdot d\bar{s} = A E_{1x} = \frac{Q}{\epsilon_0} = -\frac{e}{\epsilon_0} n_0 A \delta x$$

$$E_{1x} = \frac{-e}{\epsilon_0} n_0 \delta x$$

given eqn of motion

$$\frac{d^2(\delta x)}{dt^2} + \frac{e^2 n_0}{m_s \epsilon_0} \delta(x) = 0$$