In the case of plasmas,

MKS	CGS
B	$\frac{B}{c}$
ε_0^{-1}	4π
μ_0	$\frac{4\pi}{c^2}$
e	$e\ \sqrt{4\pi\varepsilon_0}$

$$\boldsymbol{F} = q\left(\boldsymbol{E}^* + \frac{\boldsymbol{v}}{c} \times \boldsymbol{B}\right)$$ ... **electromagnetic force** (CGS unit)

q: **charge of a particle**

$$\frac{\partial f}{\partial t} + \boldsymbol{v} \bullet \frac{\partial f}{\partial \boldsymbol{x}} + \frac{q}{m}\left(\boldsymbol{E}^* + \frac{\boldsymbol{v}}{c} \times \boldsymbol{B}\right) \bullet \frac{\partial f}{\partial \boldsymbol{v}} = \left(\frac{\delta f}{\delta t}\right)_C^{**}$$

Regarding the electric field*, it is different from instantaneous electric field that arises during an event of Coulombic collision (=> particle-particle interaction via the instantaneous electric field).

Regarding the collision term**, we may consider wave-particle interaction (anomalous collision) as well as particle-particle interaction.

If collision can be neglected ($t_{phenomenon} \ll t_{collision}$),

$$\frac{\partial f}{\partial t} + \boldsymbol{v} \bullet \frac{\partial f}{\partial \boldsymbol{x}} + \frac{q}{m}\left(\boldsymbol{E} + \frac{\boldsymbol{v}}{c} \times \boldsymbol{B}\right) \bullet \frac{\partial f}{\partial \boldsymbol{v}} = 0$$

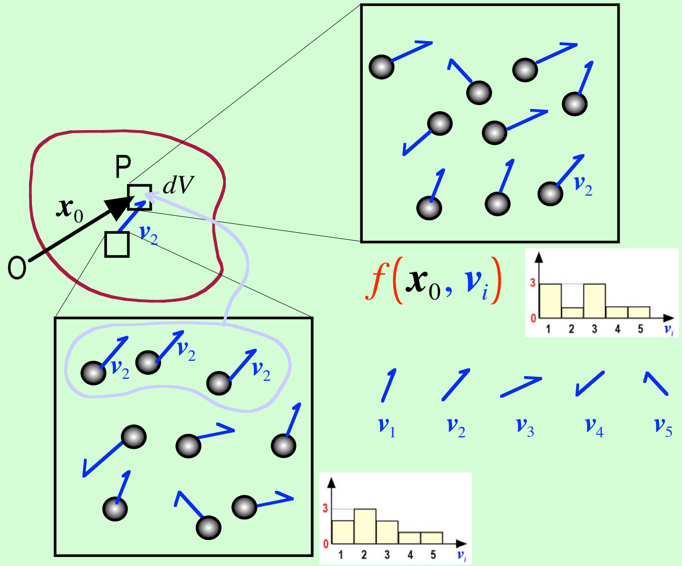
Collisionless Boltzmann's equation
or
Vlasov equation

Physical interpretation of Boltzmann's equation

We consider what causes temporal change of the distribution function at $(\boldsymbol{x}_0, \boldsymbol{v}_2)$:

$$\frac{\partial f\left(\boldsymbol{x}_0, \boldsymbol{v}_2, t\right)}{\partial t} = -\boldsymbol{v}_2 \bullet \left.\frac{\partial f\left(\boldsymbol{x}, \boldsymbol{v}_2, t\right)}{\partial \boldsymbol{x}}\right|_{\boldsymbol{x}=\boldsymbol{x}_0} - \frac{\boldsymbol{F}}{m} \bullet \left.\frac{\partial f\left(\boldsymbol{x}_0, \boldsymbol{v}, t\right)}{\partial \boldsymbol{v}}\right|_{\boldsymbol{v}=\boldsymbol{v}_2} + \left(\frac{\delta f}{\delta t}\right)_C$$

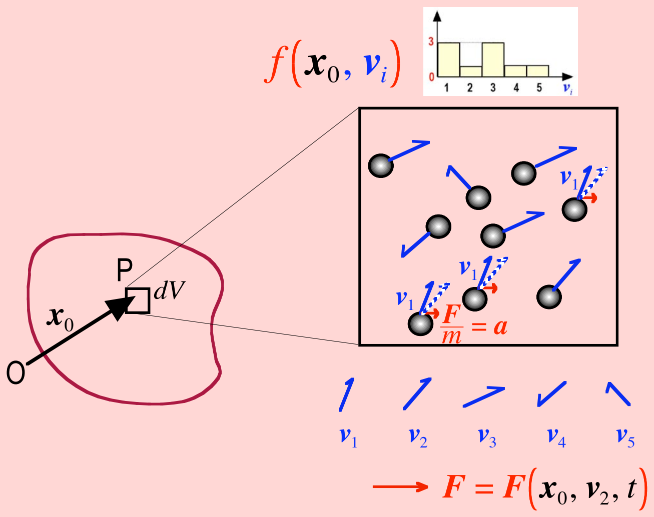
1st term: **flow effect** $-\boldsymbol{v}_2 \bullet \left.\frac{\partial f\left(\boldsymbol{x}, \boldsymbol{v}_2, t\right)}{\partial \boldsymbol{x}}\right|_{\boldsymbol{x}=\boldsymbol{x}_0}$



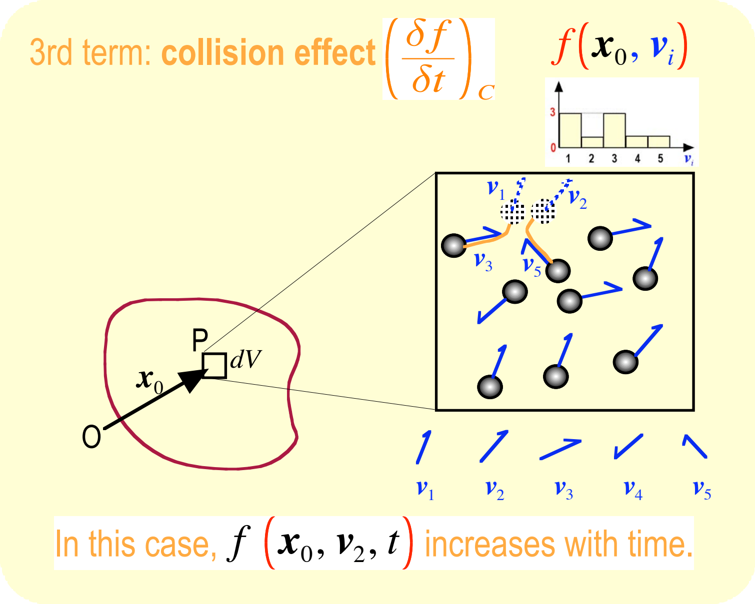
In this case, $f\left(\boldsymbol{x}_0, \boldsymbol{v}_2, t\right)$ increases with time.

2nd term: **force effect** $-\frac{\boldsymbol{F}}{m} \bullet \left.\frac{\partial f\left(\boldsymbol{x}_0, \boldsymbol{v}, t\right)}{\partial \boldsymbol{v}}\right|_{\boldsymbol{v}=\boldsymbol{v}_2}$

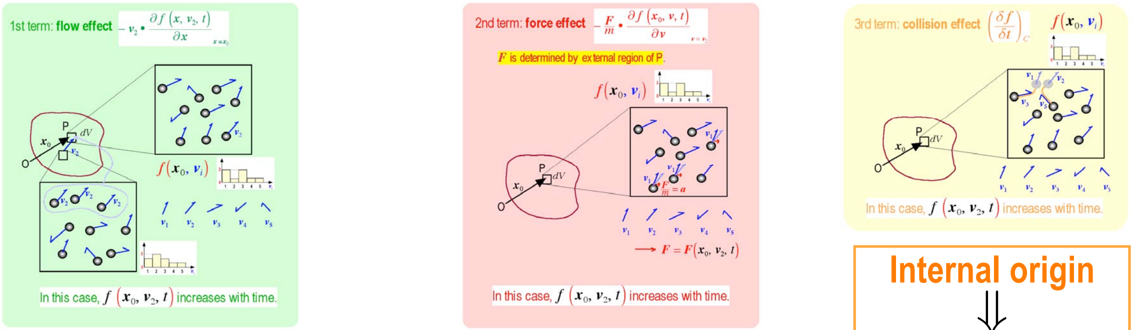
$\boldsymbol{F}$ is determined by external region of P.



In this case, $f\left(\boldsymbol{x}_0, \boldsymbol{v}_2, t\right)$ increases with time.



$$\frac{\partial f(\boldsymbol{x}_0, \boldsymbol{v}_2, t)}{\partial t} = -\boldsymbol{v}_2 \bullet \left.\frac{\partial f(\boldsymbol{x}, \boldsymbol{v}_2, t)}{\partial \boldsymbol{x}}\right|_{\boldsymbol{x}=\boldsymbol{x}_0} - \frac{\boldsymbol{F}}{m} \bullet \left.\frac{\partial f(\boldsymbol{x}_0, \boldsymbol{v}, t)}{\partial \boldsymbol{v}}\right|_{\boldsymbol{v}=\boldsymbol{v}_2} + \left(\frac{\delta f}{\delta t}\right)_C$$



Internal origin

⇓

source term

External origins

Average of Boltzmann's equation based on Maxwellian distribution function

from particle to fluid element