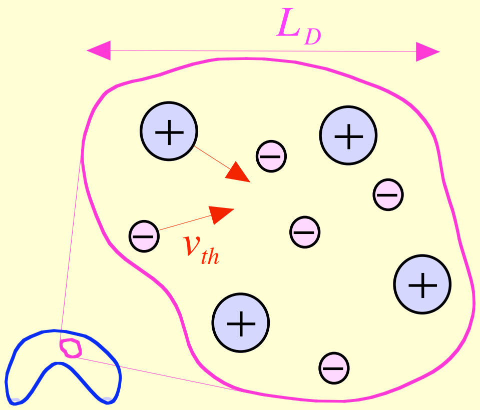
# *Typical scales in both approaches...*

## Kinetic approach... **particle** is a fundamental object (its internal structure is not considered)




$v_{th} = \sqrt{\frac{k_B T}{m}}$ : *thermal speed*

**Typical scales:**

Length... $L_D$ (Debye length)

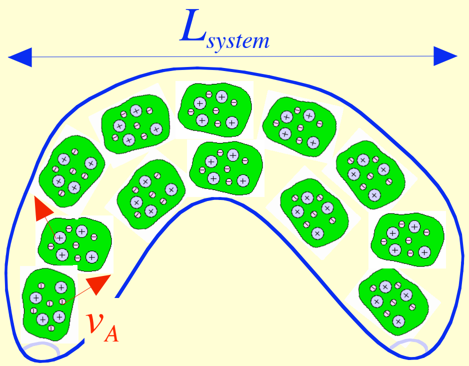
e.g., 4 m for a solar coronal plasma

1 cm

Time... $L_D / v_{th} \sim 1 / \nu_p$ (plasma frequency)

e.g., $5 \times 10^{-9}$ s for a solar coronal plasma

## Fluid approach... **fluid element** is a fundamental object (its internal structure is not considered)



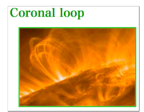

$r_{particle} << L_D << l_{mfp} << L_{FE} << L_{system}$

$r_G << L_{FE}$

**Typical scales:**

Length... $L_{system}$ (System size)

e.g., 100,000 km ~ $10^8$ m for a coronal loop



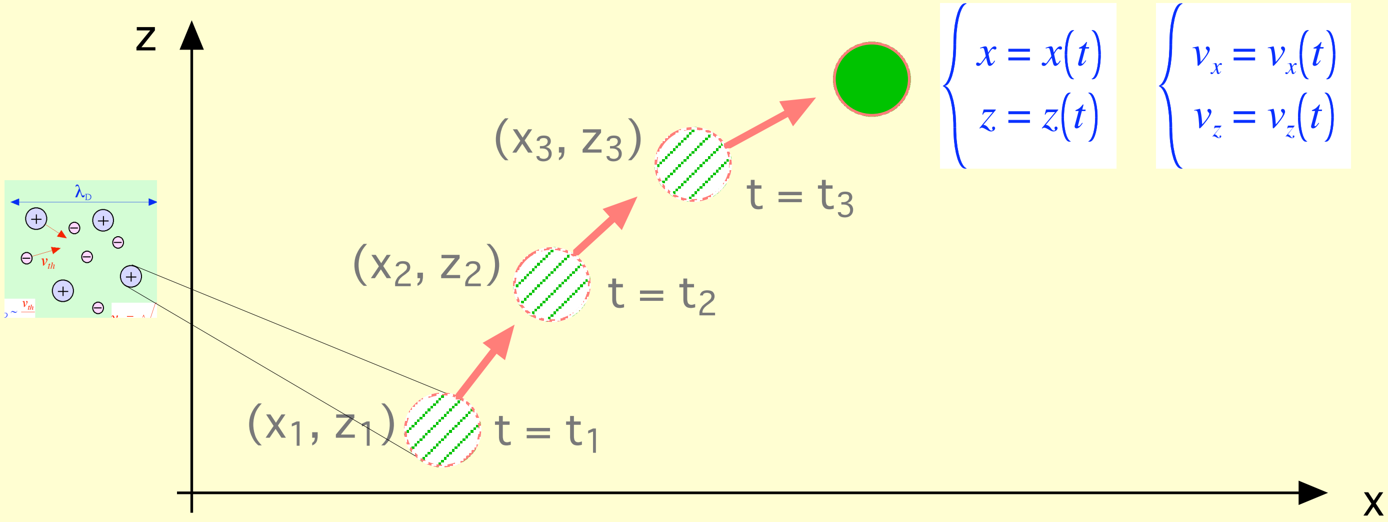

Time... $L_{system} / v_A$ ($v_A = \frac{B}{\sqrt{\mu_0 n m}}$: *Alfvén speed*)

e.g., 100 s for a coronal loop ($v_A$ ~ 1000 km/s)

# Basic equations in kinetic & fluid approaches

***Kinetic approach...*** Focus on the position and velocity of a particle at every time

**=> Mechanical equation**




$$\begin{cases} x = x(t) \\ z = z(t) \end{cases} \qquad \begin{cases} v_x = v_x(t) \\ v_z = v_z(t) \end{cases}$$

In the kinetic approach, we consider the **physical state** of a **particle** represented by its **position** and **velocity**.

The mechanical equation is a **differential equation** where **time** is the **only independent variable** (ordinary differential equation, ODE).

$$\begin{cases} m\dfrac{dv_x}{dt} = F_x\big(x(t), z(t), v_x(t), v_z(t), t\big) \\ m\dfrac{dv_z}{dt} = F_z\big(x(t), z(t), v_x(t), v_z(t), t\big) \end{cases} \qquad \begin{cases} \dfrac{dx}{dt} = v_x(t) \\ \dfrac{dz}{dt} = v_z(t) \end{cases}$$