Chapter 2

Kinetic Theory of Aether Particles

2.1 Basic Concepts and Assumptions

This chapter will derive energy density and pressure from particles collision on a surface based on kinetic theory. Kinetic theory considers only collision motion of aether particles. The root-mean-square of collision speed v_c will be shown to be almost constant in the universe and is proportional to the speed of light c.

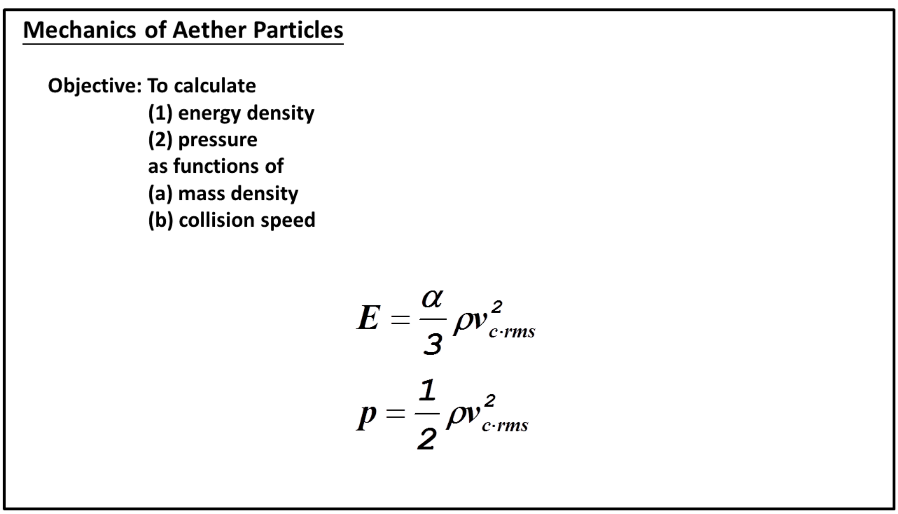

Fig.2.1 Mechanics of Aether Particles

The basic concepts and assumptions are summarized as follows:

1. In a mechanical aether model, an aether particle has two basic microscopic motions that: (1) moving in straight line and (2) spin about its center. The straight line movement will hit or collide with another particle.

2. Both colliding and spin motions are represented by vectors to show the directions and the magnitudes of the motions.
3. The directions and the magnitudes of both colliding and spin motions will change after each collision.
4. The directions of both colliding and spin motions point to random directions in space. The magnitudes of the velocities of both colliding and spin motions are Maxwell's distributed.

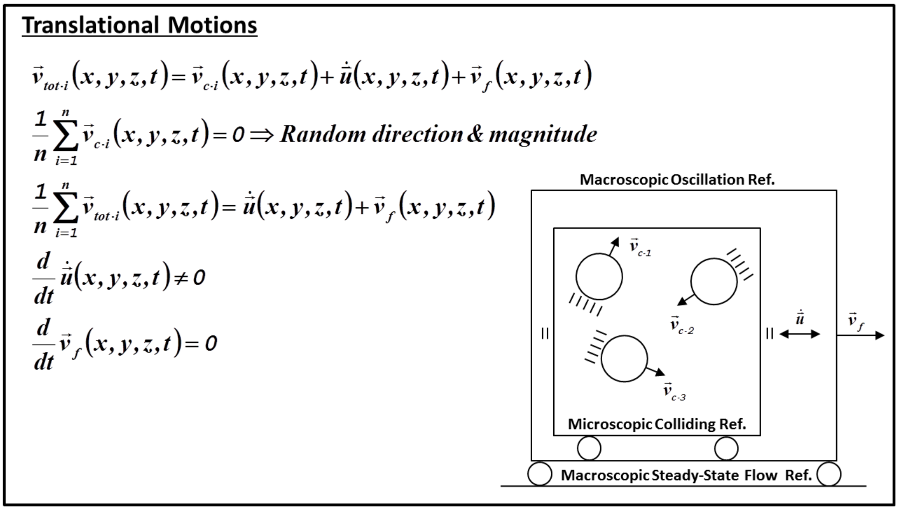

Fig.2.2 Translational Motions of Aether Particles

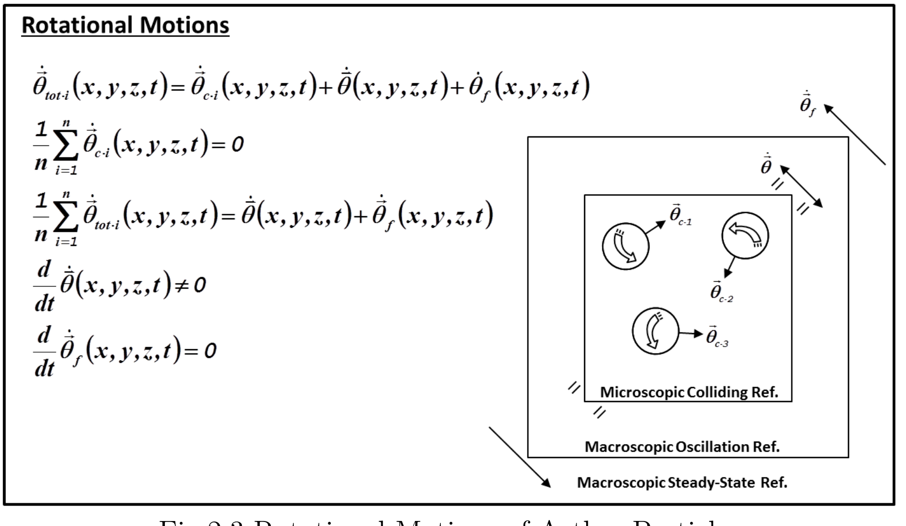

Fig.2.3 Rotational Motions of Aether Particles

2.2 Energy Density of a Single Aether Particle

In classical mechanics, any moving particle with mass and which occupies a volume in space has mass density and energy density. When this moving particle collides into a surface, this collision produces a pressure on the surface. This section discusses the mass density, energy density, and collision pressure of a single perfect elastic aether particle.

Kinetic energy of one particle moving at a constant speed is shown below.

$$K_a \equiv \frac{1}{2} m_a v_{ca}^2 \tag{2.1}$$

where

K_a is kinetic energy of one particle,
m_a is mass of one particle,
v_{ca} is collision speed of one particle.

Note that, the subscript c in v_{ca} represents collision and a in v_{ca} represents one particle.

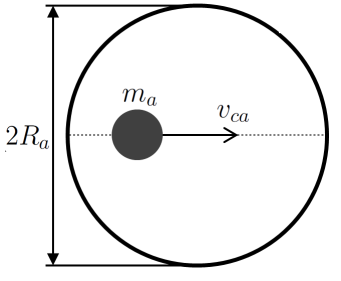

Fig.2.4 One Particle inside a Sphere

Assume this particle is moving inside a spherical ball with a radius R_a as shown in Fig.2.4. Aether energy density is calculated from dividing kinetic energy by the volume occupied by this particle.

$$E \equiv \frac{K_a}{V_a} = \frac{1}{2} \frac{m_a}{V_a} v_{ca}^2 = \frac{1}{2} \rho v_{ca}^2 \tag{2.2}$$

where

V_a is volume occupied by a particle,
ρ is mass density,
E is energy density of particles with constant collision speed.

2.3 Pressure due to a Single Aether Particle

We assume this single particle always passes through the center of the ball and collides into the wall of the ball without energy loss. Since it is elastic collision, the momentum change of collision is two times that of its momentum, $2m_a v_{ca}$. The reaction force on the wall can be determined by the conservation of momentum as shown below.

$$F_a = \frac{\Delta(m_a v_{ca})}{\Delta t} = \frac{2m_a v_{ca}}{\frac{2R_a}{v_{ca}}} = \frac{m_a v_{ca}^2}{R_a} \tag{2.3}$$

The average aether pressure of particles can be calculated from dividing collision force by the total surface area as

$$p = \frac{F_a}{4\pi R_a^2} = \frac{\frac{m_a v_{ca}^2}{R_a}}{4\pi R_a^2} = \frac{m_a v_{ca}^2}{4\pi R_a^3} \tag{2.4}$$

where

p is pressure from collision of particles,
F_a is collision force on the wall,
Δt is the duration between two adjacent collisions,
R_a is radius of the spherical ball occupied by one particle.

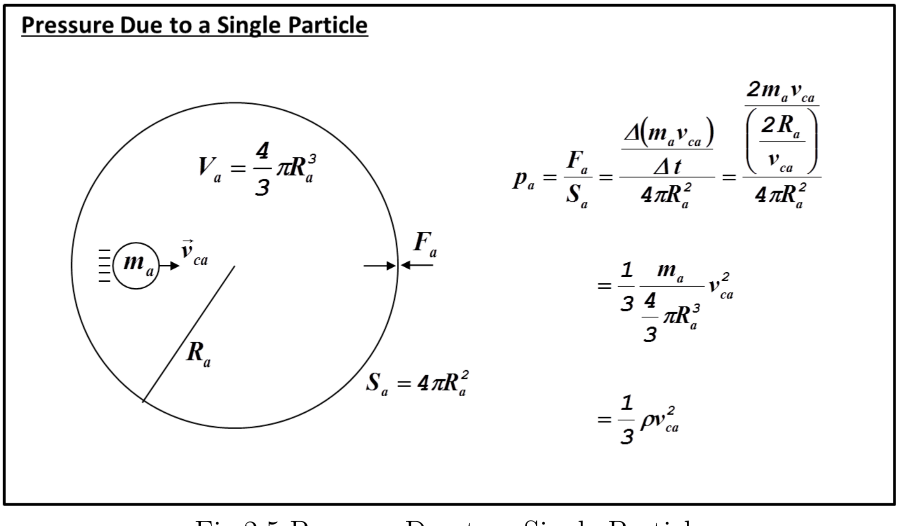

Fig.2.5 Pressure Due to a Single Particle

Replace mass with mass density in Eq.(2.4) and note that $V_a = \frac{4\pi R_a^3}{3}$ to get

$$p = \frac{m_a v_{ca}^2}{3V_a} = \frac{1}{3}\rho v_{ca}^2 \tag{2.5}$$

2.4 Root-Mean-Square of Collision Speed

Based on constant mass m_a and constant collision speed v_{ca}, energy density E and pressure p are calculated for a single aether particle in the previous section. Since both energy density E and collision pressure p are proportional to the square of collision speed v_c^2 when mass density ρ is constant, average energy density E_{avg} and average collision pressure p are proportional to the square of root-mean-square of speed as

$$E_{avg} = \frac{1}{n}\left[\sum_{i=1}^{n}\frac{1}{2}\rho v_{ci}^2\right] = \frac{1}{2}\rho\left[\frac{1}{n}\sum_{i=1}^{n} v_{ci}^2\right] = \frac{1}{2}\rho v_{c\cdot\mathrm{r}ms}^2 \tag{2.6}$$

Where

E_{avg} : Average energy density,

n : Number of particles,

ρ : Mass density,

v_{ci} : Collision speed of particle i,

$v_{c\cdot\mathrm{r}ms}$: Root-mean-square of collision speed.

$$v_{c\cdot\mathrm{r}ms} = \sqrt{\frac{1}{n}\sum_{i=1}^{n} v_{ci}^2} \tag{2.7}$$

The same arguments hold for collision pressure.

$$p_{avg} = \frac{1}{n}\left[\sum_{i=1}^{n}\frac{1}{3}\rho v_{ci}^2\right] = \frac{1}{3}\rho\left[\frac{1}{n}\sum_{i=1}^{n} v_{ci}^2\right] = \frac{1}{3}\rho v_{c\cdot\mathrm{r}ms}^2 \tag{2.8}$$

2.5 Maxwell's Distribution of Collision Speed

Assume every aether particle has the same mass and moves randomly in all directions. Furthermore, assume that the collision speed of aether particles follows Maxwell's speed distribution as

$$\psi(v) \quad = \quad \frac{4v^2}{\sqrt{\pi}\hat{v}_c^3} e^{-v^2/\hat{v}_c^2} \tag{2.9}$$

where

$\psi(v)$ is Maxwell's speed distribution,
$\hat{v}_c$ is collision speed at maximum probability.

The root-mean-square speed of a group of particles is shown below to be linearly related to the particle collision speed at its maximum probability $\hat{v}_c$. Note that speed v_c without hat represents root-mean-square (RMS) speed, and with hat represents the maximum probability speed of Maxwell's distribution. Therefore, the RMS speed of Maxwell's distributed collision speed can be written as

$$v_c^2 \quad \equiv \int_0^\infty v^2 \psi(v) dv = \frac{3}{2}\hat{v}_c^2 \tag{2.10}$$

Therefore, aether energy density is

$$E = \frac{1}{2}\rho v_c^2 = \frac{3}{4}\rho \hat{v}_c^2 \tag{2.11}$$

Similarly, aether pressure is

$$p = \frac{1}{3}\rho v_c^2 = \frac{1}{2}\rho \hat{v}_c^2 \tag{2.12}$$

Both aether energy density and pressure are linearly related to aether mass density and collision speed square at maximum probability as shown in Eq.(2.11) and Eq.(2.12), and aether pressure can be expressed in terms of aether energy as

$$p = \frac{2}{3}E \tag{2.13}$$

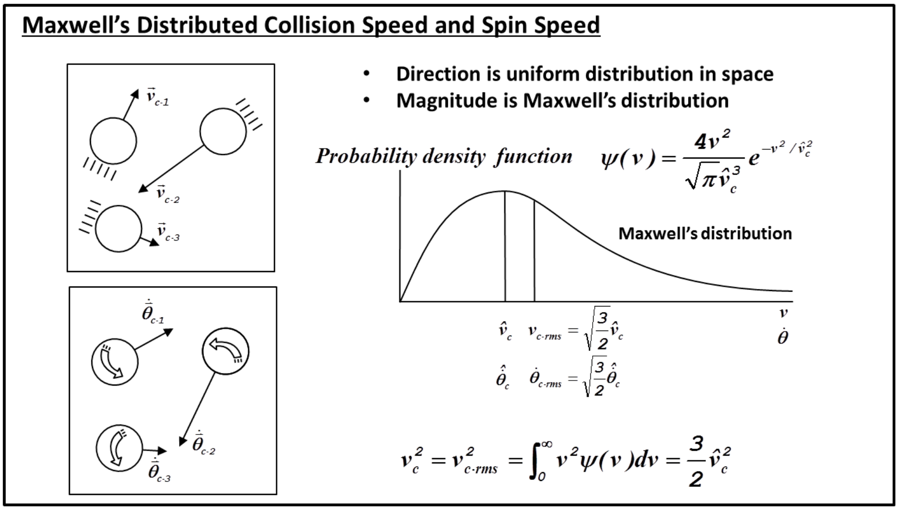

Fig.2.6 Maxwell's Distributed Collision Speed and Spin Speed

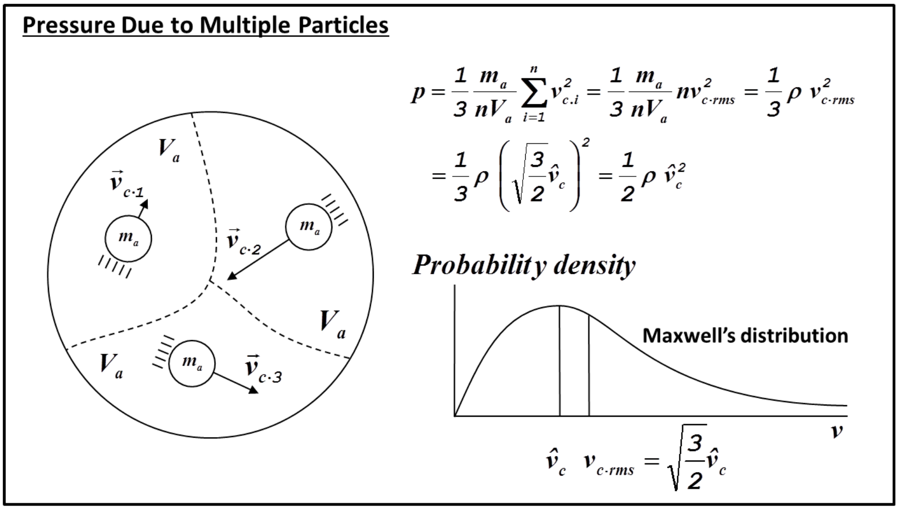

Fig.2.7 Pressure Due to Multiple Particles

2.6 Ideal Gas Formula

Ideal gas formula can be derived from Eq.(2.14), for n mole gas by replace mass density with mass and volume occupied by n mole gas as

$$p = \frac{1}{3}\frac{m}{V}v_c^2 = \frac{1}{3}\frac{nN_A m_a}{V}v_c^2 \tag{2.14}$$

where

n is number of mole of gas,
N_A is Avogadro constant
represent the number of particles (molecules) per mole,
m is total mass of n mole gas($= nN_A m_a$),
V is total volume occupied by n mole gas.

Rewrite Eq.(2.12) to get

$$pV = n(\frac{N_A m_a v_c^2}{3}) \tag{2.15}$$

$\frac{N_A m_a v_c^2}{3}$ is proportional to total kinetic energy of gas. Also, temperature is proportional to the total kinetic energy. Therefore, Eq.(2.15) can be written as the ideal gas formula by transferring kinetic energy into temperature through gas constant R.

$$R = \frac{N_A m_a v_c^2}{3T} \tag{2.16}$$

Substitute Eq.(2.16) into Eq.(2.15) to get

$$pV = nRT \tag{2.17}$$

Even though Eq.(2.17) and Eq.(2.12) have the same meaning in physics, Eq.(2.17) relates pressure with temperature while Eq.(2.12) relates pressure with particle collision speed.

2.7 Mass Density and Root-Mean-Square Speed

To consider the energy of the spin particles, assume that the spin energy is proportional to the colliding energy. The ratio of spin energy to colliding energy is $(\alpha - 1)$, where $\alpha >= 1$. And the total energy will be modified by an α factor.

The energy density and collision pressure had been shown to be related to mass density ρ and root-mean-square speed v_c as

$$E = \frac{\alpha}{2}\rho v_c^2 \tag{2.18}$$

$$p = \frac{1}{3}\rho v_c^2 \tag{2.19}$$

$$p = \frac{1}{3\alpha}E \tag{2.20}$$

Where v_c is root-mean-square speed of randomly distributed collision speed of aether particles.

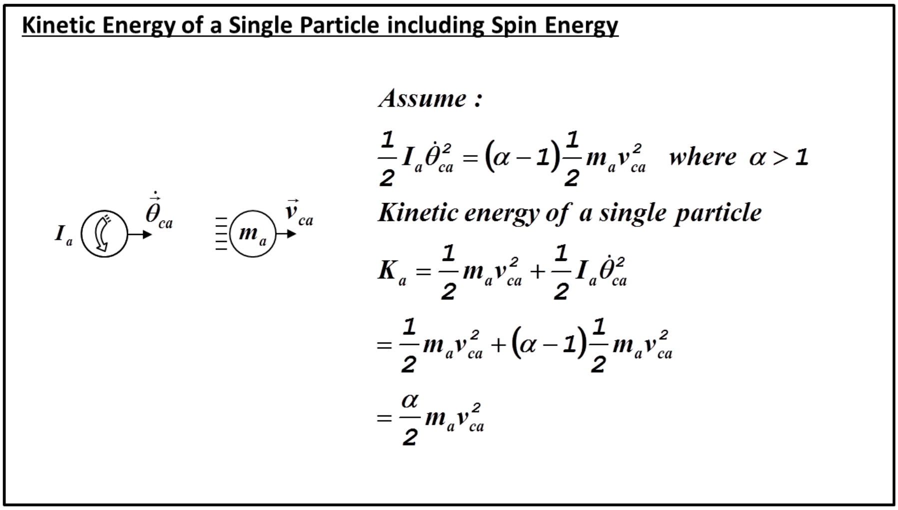

Fig.2.8 Kinetic Energy of a Single Particle including Spin Energy

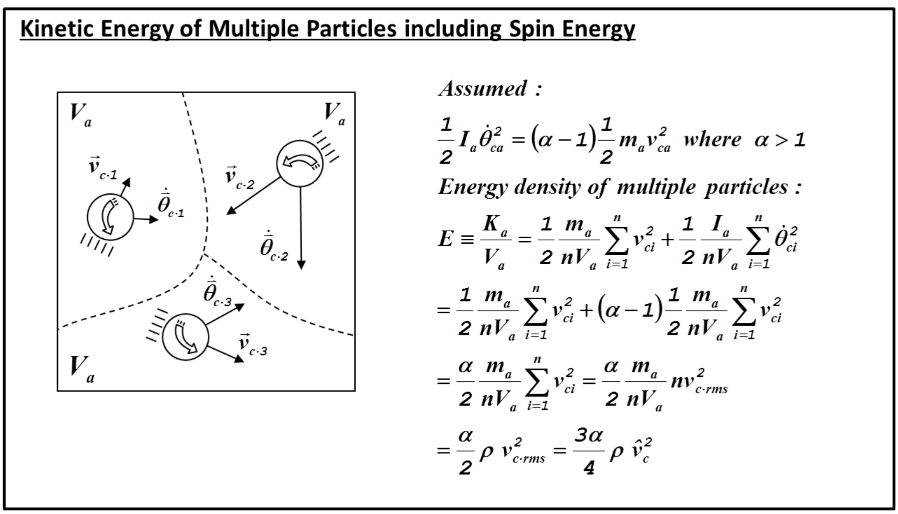

Fig.2.9 Kinetic Energy of Multiple Particles including Spin Energy

The root-mean-square speed v_c and mass density ρ are functions of position and time as

$$v_c(x, y, z, t) \tag{2.21}$$

$$\rho(x, y, z, t) \tag{2.22}$$

Therefore, energy density E and collision pressure p are also functions of position and time as

$$E(x, y, z, t) \tag{2.23}$$

$$p(x, y, z, t) \tag{2.24}$$

Since all of energy density E, collision pressure p, root-mean-square speed v_c and mass density ρ are functions of position and time, all of them can be called fields.

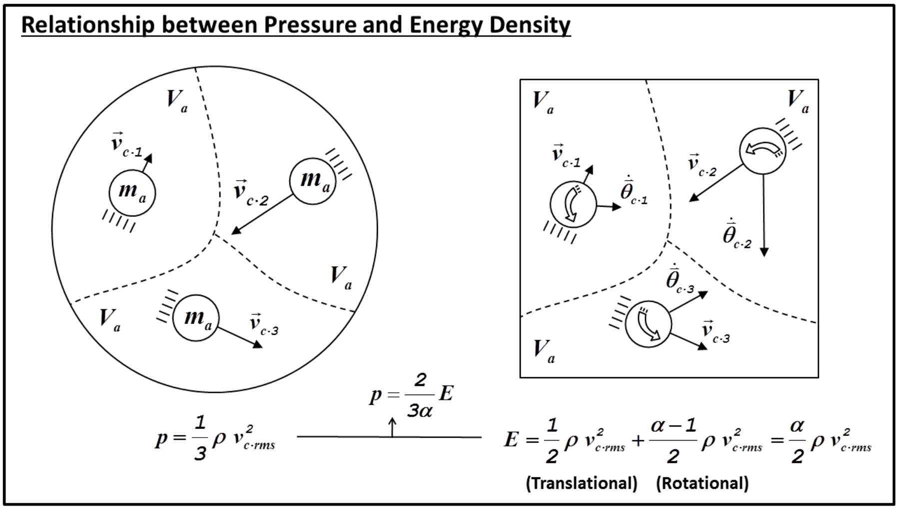

Fig.2.10 Relationship between Pressure and Energy Density

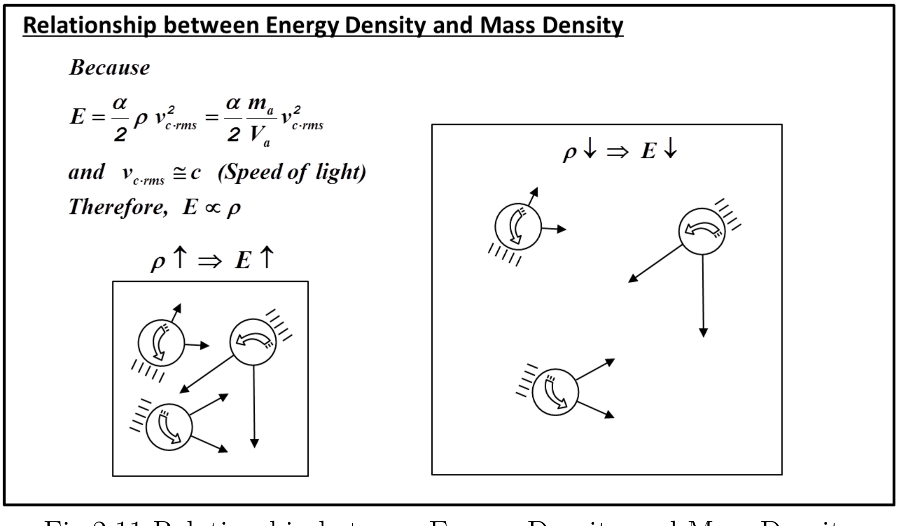

Fig.2.11 Relationship between Energy Density and Mass Density