E-Content of PLASMA

Physics MSc Semester II

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By:-

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Concept of Temperature

A gas in thermal equilibrium has particles of all velocities, and the most probable distribution of these velocities is known as the Maxwellian distribution. Let us consider a gas in which the particles can move only one dimension in a strong magnetic field. If the electron move only along the field line the one diamensioral Maxwellian distribution is given by

$$f(u) = A \exp\left(-\tfrac{1}{2} m u^2 / KT\right)$$

where $f du$ is the number of particles$/m^3$ with velocity between u and $u+du$, $\frac{1}{2}mu^2$ is the kinetic energy and K is Boltzmann constant.

$$K = 1.38 \times 10^{-23}\ J/^{o}K$$

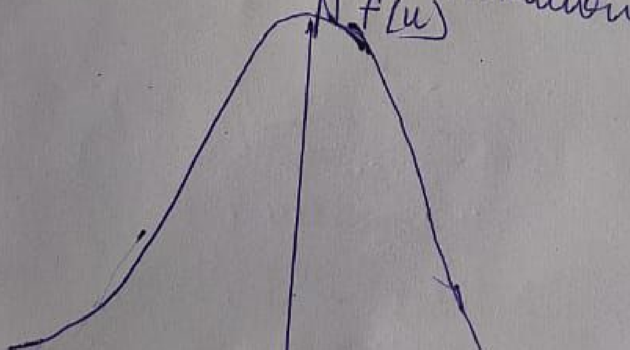
The density n, or number of particles$/m^3$ is given by

$$A = n\left(\frac{m}{2\pi KT}\right)^{\frac{1}{2}} \qquad n = \int_{-\infty}^{\infty} f(u)\,du$$

~~The width~~

A is a constant. T is the temperature

~~The~~ Maxwell velocity distribution in shown in fig 1



The average kinetic energy of particle in Maxwell's distribution.

$$\frac{\int_{-\infty}^{\infty} \frac{1}{2} m u^2 f(u) du}{\int_{-\infty}^{\infty} f(u) du} \quad \text{---} \boxed{4}$$

where $u_{th} = \left(\frac{2kT}{m}\right)^{\frac{1}{2}}$ and $y = u/v_{th}$ ---$\boxed{5}$

we can write equation $\boxed{1}$ as

$$f(u) = A \exp\left(-u^2/v_{th}^2\right) \quad \text{---} \boxed{6}$$

Therefore eq ① can be written

$$\frac{\frac{1}{2} m A u_{th}^3 \int_{-\infty}^{\infty} [\exp(-y^2) y^2 dy}{A v_{th} \int_{-\infty}^{+\infty} \exp(-y^2) dy}$$

The integral in the numerator is integrable by parts

$$\int_{-\infty}^{\infty} y \cdot [\exp(-y^2) y \, dy = \left[-\frac{1}{2} [\exp(-y^2)] y \right]_{-\infty}^{\infty} - \int_{-\infty}^{\infty} -\frac{1}{2} \exp(-y^2) dy$$

$$= \frac{1}{2} \int_{-\infty}^{\infty} \exp(-y^2 dy)$$

Cancelling the integrals

$$E_{av} = \frac{\frac{1}{2} m A u_{th}^3 \frac{1}{2}}{A v_{th}} = \frac{1}{4} m v_{th}^2 = \frac{1}{2} KT$$

Thus the average is $1/2 \, KT$

In three diamension

$$E_{av} = \frac{3}{2} KT$$

Energy in three degrees of freedom
In plasma physics temperature has unit of energy. The energy corresponds to KT. for $KT = 1ev = 1.6 \times 10^{-19}$ Joule
Then we have

$$\therefore T = \frac{1.6 \times 10^{-19}}{1.38 \times 10^{-23}} = 11.600$$

$$\therefore 1ev = 11.600^{0} K.$$

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