Thermal Physics

(Maxwell Distribution Law)

Lecture -7

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$b = m/ 2kT$ (25)

Using the values of a and b , Maxwell distribution law of velocities can be written in the form .

$dn_c = n_c\, dc = 4\pi n (m/ 2nkT)^{3/2} e^{-mc^2/2kT} c^2\, dc$ (26)

The quantity

$f (c) = dn_c /ndc = 4\pi^{-1/2} (m/ 2kT)^{3/2} c^2 \exp (- mc^2 / 2kT)$ (27)

It is the distribution function of velocities of molecules by velocities .

From kinetic theory of gas , the pressure P exerted by gas is

$$P = 1/3\ mN / V\ c^2 \qquad (21)$$

Where c^2 is mean square velocity , which is defined as

$$c^2 = 1/n \int_0^{\infty} c^2\, dn_c$$

$$= 4\,\pi\, a^3 \int_0^{\infty} e^{-bc^2} c^4\, dc \qquad (22)$$

$bc^2 = X$, we get ,

$c^2 = 2\pi a^3 / b^{5/2} \int_0^{\infty} e^{-X} X^{1/2} dX$

$= 2\pi a^3 / b^{5/2} ¾ \pi^{1/2}$

$= 3/2b$

Then , $P = mN / 2Vb$ (23)

But for ideal gas

$P = NkT / V$ (24)

Maxwell distribution some times also called Maxwell Boltzmann distribution law in an equilibrium distribution law .

Experimental verification .

Stern's Experiment : In 1947 , Stern , Estermann and simpson arranged an experiment for verifying the Maxwell law of velocity distribution .

The experimental arrangement is shown in fig 2. .The apparatus consists of an open vessel having hot gas with a narrow horizontal opening hole .

Cesium is taken as the source of atoms , which is heated in the oven .

A nozzle slit is placed at a distance of 1meter from it ,

A thin tungsten wire placed at a distance of 1 meter from the slit S .

It serves as a target . The entire arrangement are along one strictly horizontal line .

The entire arrangement is enclosed in a highly evacuated chamber .

The cesium atoms flow out of the oven through nozzle .

In the absence of gravitational field ,they would strike the target .

However due to gravitational field the atoms travel along parabola .The atoms emerging from nozzle with a velocity horizontally along the X – axis will not pass through the narrow slit and will not reach the target .

The atoms emerging from slit at a small angle θ and will pass through another slit and strike the target .

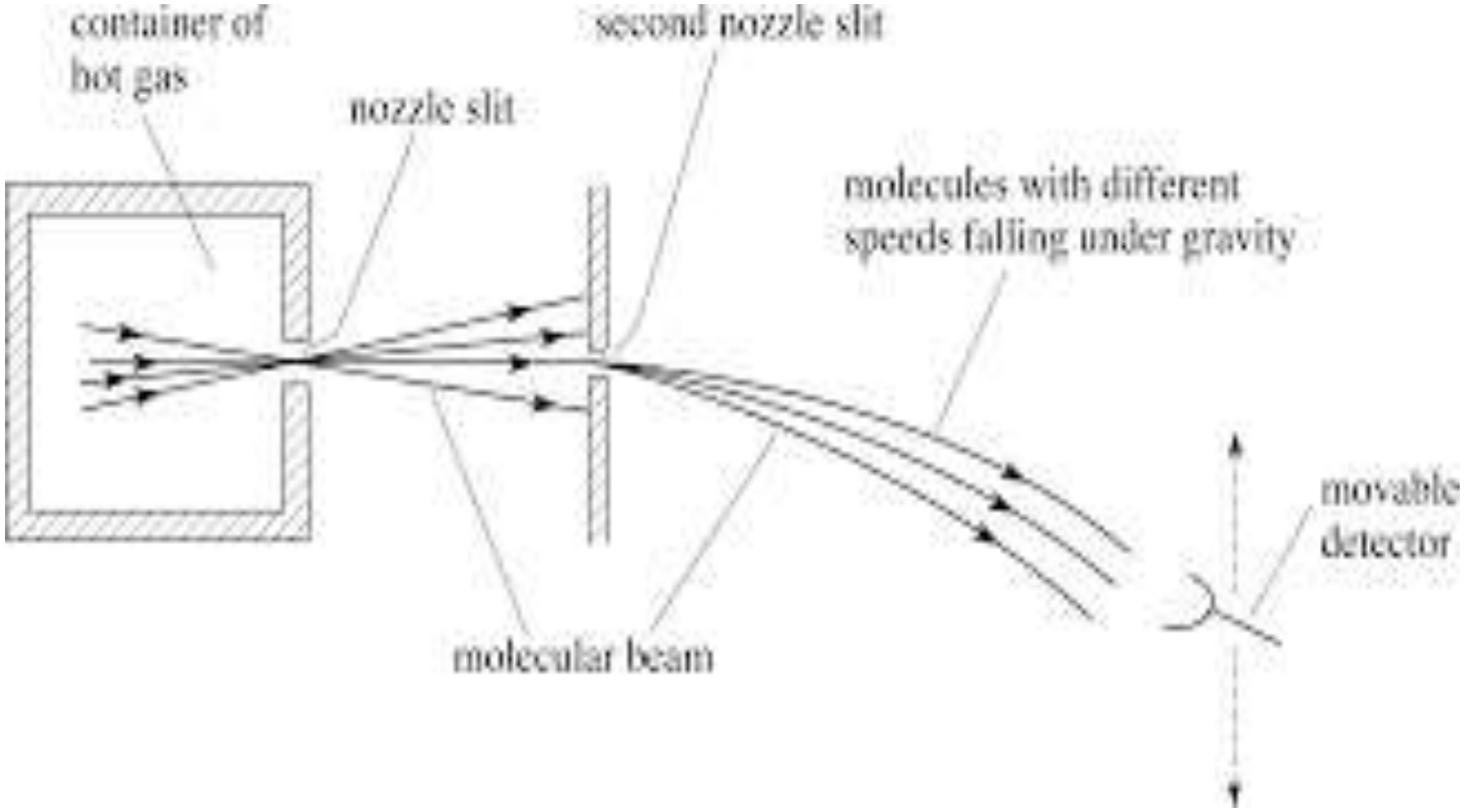

Figure.3 Apparatus of Stern's improved experiment

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The tungsten wire –target is heated by an electric current passing through it .

When cesium atoms strike the wire –target , they get ionized . These positively charged ions , leaving the target , get into the negatively charged cylinder surrounding the target .

Thus an electric current of ions passes between the wire and the cylinder , which can be measured with accuracy .

The ionic current gives the number of atoms hitting the target.

Moving the target in a vertical direction at different positions , the ionic current and hence the number of atoms hitting the target is measured at different heights .

We find the number of atoms having different velocities – the atoms hitting target have velocity higher than those at different point .

This gives us the distribution of atoms with velocities . This is in complete agreement with the Maxwell distribution law of velocities .