B.SC-III, paper-VII, group-A

STERN-GARLACH Experiments—

In 1922 experimental evidence of $\bar{e}$ spin but a direct demonstration of space quantization of atoms also thus providing an experimental verification of the salient features of the vector atom model.

In the experiment however, there was no band, but discrete traces on the photographic plate. This showed that the atoms passing through the field were oriented in space in discrete directions. so that the beam deflected in certain discrete directions only and gave discrete traces on the plate.

The total magnetic dipole moment and the total angular momentum $\vec{J}$

$$\vec{\mu_j} = -g_j \frac{e}{2mc} \vec{J}$$

$$\mu_{j_z} = g_j \frac{e}{2mc} J_z$$

$$= g_j \frac{e}{2mc} m_j \frac{h}{2\pi}$$

$$\boxed{\mu_{j_z} = g_j m_j \mu_B}$$ $g_j \to g$ factor.

$$F_z = \frac{\partial B_z}{\partial z} g_j m_j \mu_B.$$

$\frac{\partial B_z}{\partial z}$ → rate of change of field in the z direction and μ_{jz} is the z component of the total (O+S) mag. moment $\vec{\mu_j}$ of an atom.

$$a_z = \frac{F_z}{M} = \frac{1}{M} \frac{\partial B_z}{\partial z} g_j M_j \mu_B.$$

a_z → acceleration along z direction

$$t = \frac{d}{v_x} \quad \frac{\text{length of their path}}{\text{longitudinal velocity}}$$

But K.E, the velocity v_x of an atom of mass M is

$$\tfrac{1}{2} M v_x^2 = \tfrac{3}{2} kT$$

k → Boltzmann constant
T → Kelvin Temp.

$$t = d\sqrt{\frac{M}{3kT}}$$

so, $z = \tfrac{1}{2} a_z t^2$

$$= \frac{1}{2} \frac{1}{M} \frac{\partial B_z}{\partial z} g_j M_j \mu_B \cdot d^2 \left(\frac{M}{3kT}\right)$$

$$= \frac{g_j M_j \frac{\partial B_z}{\partial z} \mu_B d^2}{6kT}$$

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