Langevin's theory of diamagnetism - lecture -2

When a magnetic field H is applied perpendicular to the plane of the orbit of this electron , the additional force due to magnetic field ,

$$\Delta F = Hev = Hea\omega$$

$$V = a\omega \qquad (4)$$

Which is acting radially inward on the electron and it is perpendicular to both the orbit and magnetic field . Hence this force and the coulomb force of attraction acting on the electron in the same direction .

Resultant force acting on the electron in the magnetic field

$$= - (m\omega^2 a + He a\omega) \qquad (5)$$

The effect of this force is to change the angular velocity of the electron without affecting the radius of the orbit . If $\omega + \Delta\omega$ is the new angular velocity of the electron , then the magnetic moment in this case

$$M + \Delta M = -1/2\, e\, (\omega + \Delta\omega)\, a^2 \qquad (6)$$

The change in magnetic moment is

$$\Delta M = -1/2\, e\, (\omega + \Delta\omega)\, a^2 + ½\, e\omega\, a^2$$

$$= -1/2\, e\, [\omega + \Delta\omega - \omega]\, a^2$$

$$= -1/2\, e\, (\Delta\omega)\, a^2 \qquad (7)$$

$$F = m\, \omega^2\, a$$

$$\Delta F = 2\,m\,a\,\omega\;\Delta\omega \qquad (8)$$

$$\Delta F = He a\omega \qquad (9)$$

$$2ma\omega\Delta\omega = Hea\omega$$

$$\Delta\omega = He/2m \qquad (10)$$

Putting the value of $\Delta\omega$ from (10) in (7)

$$\Delta M = - e^2 a^2 (He /2m)$$

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Let us suppose that when the orbit of an electron is not perpendicular to the applied field , then the projection a_1 , of the radius a of the orbit on the plane perpendicular to the magnetic field is taken in place of a .

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Hence we can write

$$\Delta M = - e^2 a_1^2 \ (He /4m) \qquad (12)$$

Let the coordinates of the radius of the orbit are x, y z . Then we have $a^2 = x^2 + y^2 + z^2$