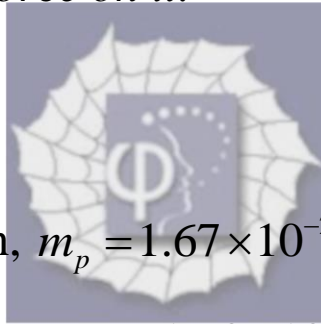**425.**

Problem 34.5 (RHK)

A cosmic ray proton impinges on the Earth near the equator with a vertical velocity of 2.8×10^7 m s^{-1}. We may assume that the horizontal component of the Earth's magnetic field at the equator is 30 μT. We have to calculate the ratio of the magnetic force on the proton to the gravitational force on it.

Solution:

Mass of the proton, $m_p = 1.67 \times 10^{-27}$ kg;

Charge of the proton, $e_p = 1.60 \times 10^{-19}$ C;

Velocity of the proton, $v = 2.8 \times 10^7$ m s^{-1};

and the Earth's magnetic field at the equator,

$B = 30 \ \mu T = 30 \times 10^{-6}$ T.

At the equator the Earth's magnetic field in the north-south direction and as the proton is coming down vertically, the velocity vector of the proton and the

Earth's magnetic field vector will be orthogonal.

Magnetic force on proton will be

$$\vec{F}_{mag} = e_p \vec{v} \times \vec{B} = e_p v B \hat{n},$$

where $\hat{n}$ is the unit vector in the east-west direction.

Therefore,

$$\left| \vec{F}_{mag} \right| = e_p v B = 1.60 \times 10^{-19} \times 2.8 \times 10^7 \times 30 \times 10^{-6} = 1.34 \times 10^{-16} \text{ N.}$$

The gravitational force on the proton will be

$$F_{gra} = m_p g = 1.67 \times 10^{-27} \times 9.81 \text{ N} = 1.64 \times 10^{-26} \text{ N.}$$

$$\therefore \quad \frac{F_{mag}}{F_{gra}} = \frac{1.34 \times 10^{-16}}{1.64 \times 10^{-26}} = 8.2 \times 10^9.$$