168(3): Interaction of Electromagnetic and gravitational fields

: Consider the interaction of electromagnetic energy density and gravitational energy density. The former is defined by

$$U = \frac{1}{2}\left(\underline{E}\cdot\underline{D} + \underline{B}\cdot\underline{H}\right) \quad -(1)$$

The total rate of doing work by the e/m field in a volume V is:

$$P = \int_V \underline{J}\cdot\underline{E}\, d^3x. \quad -(2)$$

where

$$\underline{\nabla}\times\underline{H} - \frac{\partial \underline{D}}{\partial t} = \underline{J} \quad -(3)$$

and

$$\underline{\nabla}\times\underline{E} + \frac{\partial \underline{B}}{\partial t} = \underline{0}. \quad -(4)$$

$$-(5)$$

So

$$\int_V \underline{J}\cdot\underline{E}\, d^3x = \int_V \left(\underline{E}\cdot(\underline{\nabla}\times\underline{H}) - \underline{E}\cdot\frac{\partial \underline{D}}{\partial t}\right) d^3x$$

i.e. Poynting's theorem is deduced:

$$\frac{\partial U}{\partial t} + \underline{\nabla}\cdot\underline{S} = -\underline{J}\cdot\underline{E}, \quad -(6)$$

$$\underline{S} = \underline{E}\times\underline{H}.$$

Units

$\underline{E} = JC^{-1}m^{-1}$, $\underline{D} = Cm^{-2}$, $\underline{H} = Cs^{-1}m^{-1}$

$\underline{B} = \text{tesla} = JsC^{-1}m^{-2}$,

$U = Jm^{-3}$.

So the power P in eq. (2) is the conversion of

2)

electromagnetic energy to other forms of energy, notably gravitational energy.

Similarly, the total rate of doing work by the gravitational field of note 168(2) in a volume V is:

$$P_g = \int_V \underline{J}_m \cdot \underline{g} \, d^3x \quad -(7)$$

where $\underline{J}_m$ is the mass current density. The gravitational energy density is:

$$U_g = \frac{1}{2} \left(\underline{g} \cdot \underline{d} + \underline{b} \cdot \underline{h} \right) \quad -(8)$$

where:

$\underline{g}$ = acceleration due to gravity in $m s^{-2}$

$\underline{d}$ = gravitational displacement in $kg \, m^{-2}$

$\underline{b}$ = magneto-gravitational flux density in s^{-1}

$\underline{h}$ = magnetogravitational field strength in $kg \, m^{-1} s^{-1}$

So the units of U_g are:

$$U_g = kg \, m^{-1} s^{-2} = kgm \, m^2 s^{-2} m^{-3} = J m^{-3}$$

The gravitational Poynting Theorem is:

$$\boxed{\begin{aligned} \frac{\partial U_g}{\partial t} + \underline{\nabla} \cdot \underline{S}_g &= - \underline{J}_m \cdot \underline{g} \\ \underline{S}_g &= \underline{g} \times \underline{h} \end{aligned}} \quad -(9)$$

In these equations:

3)

$\underline{J} \cdot \underline{E}$ = work done per unit time per unit volume by the e/m field on the gravitational field

$\underline{J}_g \cdot \underline{g}$ = work done per unit time per unit volume by the gravitational field on the e/m field

<u>Units</u>

$$\underline{J} \cdot \underline{E} = C s^{-1} m^{-2} J C^{-1} m^{-1} = J s^{-1} m^{-3}$$

$$\underline{J}_g \cdot \underline{g} = kgm\, s^{-1} m^{-2} m s^{-2} = kgm\, s^{-3} m^{-1}$$
$$= kgm\, m^2 s^{-2} s^{-1} m^{-3} = J s^{-1} m^{-3} \checkmark$$

If the two fields are in balance:

$$\boxed{\underline{J} \cdot \underline{E} = \underline{J}_g \cdot \underline{g}} \quad -(10)$$

Consider the Z axis for simplicity, then:

$$\boxed{g_Z = \frac{J_Z E_Z}{J_{gZ}}} \quad -(11)$$

<u>Counter Gravitation</u>

In order to lessen g_Z, point E_Z in the opposite direction. In order for there to be an effect of E_Z on g_Z <u>there must be present an electric current density and a mass current density.</u>