1)

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EFFECT OF GRAVITATION ON ELECTROMAGNETISM IN TERMS OF REFRACTIVE INDEX

The effect is to change:

$$\underline{\nabla} \times \underline{E}^{(a)} + \frac{\partial \underline{B}^{(a)}}{\partial t} = \underline{0} \quad \text{---(1)}$$

to

$$n\,\underline{\nabla} \times \underline{E}^{(a)} + \frac{1}{n}\frac{\partial \underline{B}^{(a)}}{\partial t} = \underline{0} \quad \text{---(2)}$$

where:

$$n = (\mu\epsilon/\mu_0\epsilon_0)^{1/2}. \quad \text{---(3)}$$

Therefore the phase is changed to:

$$\phi = \frac{\omega}{n}t - n\kappa z \quad \text{---(4)}$$

from

$$\phi = \omega t - \kappa z \quad \text{---(5)}$$

and the equation:

$$E^{(0)} = cB^{(0)} \quad \text{---(6)}$$

is changed to

$$E^{(0)} = vB^{(0)} \quad \text{---(7)}$$

where

$$v = \frac{c}{n^2}. \quad \text{---(8)}$$

Thus:

$$\boxed{\omega \to \frac{\omega}{n}, \quad \kappa \to n\kappa, \quad c \to \frac{c}{n^2}} \quad \text{---(9)}$$

2) Discussion

In this simple case, where there is no absorption the effect of gravitation is to change the refractive index. The path of a light beam is changed as it light goes through water. This is a simple classical explanation of the Eddington effect. In a red shift the frequency is lowered by $n > 1$. Therefore simple red shifts are explained by diffraction due to gravitation. More generally absorption takes place as well as diffraction, and:

$$n = n' + in'' \quad -(10)$$

$$\omega \to \frac{(n' - in'')\omega}{n'^2 + n''^2} \quad -(11)$$

$$Re(\omega) \to \frac{n'\omega}{n'^2 + n''^2} \quad -(12)$$

If:

$$n'^2 + n''^2 > n' \quad -(13)$$

then a red shift occurs, but the frequency change is different from the simple red shift.

$$\omega \to \frac{\omega}{} \quad -(14)$$

3)

If the refractive index is quantized, then the shift in ω is also quantized. Therefore quantized red shifts are explained by ECE theory, and so are anomalous shifts of the type (12). The simple red shift is explained by eqn (14).

If for some reason the refractive index n is less than one, then blue shifts occur.

Finally the Hubble Law is explained by:

$$(\Box + k_T) A^a_\mu = 0 \quad -(15)$$

which is a type of Proca equation. The link between the Proca equation and photon mass is well known, and also the link between the Proca equation and the Hubble law.