1)

97(1): Change of Polarization in Light Grazing a White Dwarf.

The basis of this calculation is the ECE Ampère Maxwell law:

$$\underline{\nabla} \times \underline{B} - \frac{1}{c^2} \frac{\partial \underline{E}}{\partial t} = \mu_0 \underline{J}_{grav} \quad (1)$$

where the current density $\underline{J}_{grav}$ is calculated from the curvature of spacetime in the vicinity of a white dwarf, given the presence of $cA^{(0)}$ and electric charge $-e$. There is no satisfactory metric currently in existence apart from the Crothers class of Ricci-flat metrics, but we can proceed using the ECE dielectric theory. In this theory,

$$\underline{E} = \frac{1}{\epsilon_0} \left(\underline{D} - \underline{P} \right), \quad \underline{B} = \mu_0 \left(\underline{H} + \underline{M} \right) \quad (2)$$

i.e. it is assumed that there is a polarization ~~and~~ $\underline{P}$ and magnetization $\underline{M}$ of spacetime itself. Here $\underline{D}$ is the electric displacement, $\underline{H}$ is the magnetic field strength, $\underline{B}$ is the magnetic flux density, $\underline{E}$ is the electric field strength, and ϵ_0 and μ_0 are the vacuum permittivity and permeability.

From eq. (2) in eq. (1):

$$\underline{\nabla} \times \underline{H} - \frac{\partial \underline{D}}{\partial t} = \underline{J} - \left(\underline{\nabla} \times \underline{M} + \frac{\partial \underline{P}}{\partial t} \right)$$

(3)

2)

Now define the current density as:

$$\underline{J} := \underline{\nabla} \times \underline{M} + \frac{\partial \underline{P}}{\partial t}. \quad - (4)$$

With this definition eq. (1) becomes:

$$\underline{\nabla} \times \underline{H} - \frac{\partial \underline{D}}{\partial t} = \underline{0} \quad - (5)$$

where:

$$\underline{H} = \frac{1}{\mu} \underline{B}, \quad \underline{D} = \epsilon \underline{E}. \quad - (6)$$

Here μ and ϵ are the permeability and permittivity respectively of curved space-time.

The solution of eq. (5) is:

$$\underline{H} = \frac{H^{(0)}}{\sqrt{2}} \left(i\underline{i} + \underline{j} \right) e^{i(\omega t - \kappa Z)} \quad - (7)$$

$$\underline{D} = \frac{D^{(0)}}{\sqrt{2}} \left(\underline{i} - i\underline{j} \right) e^{i(\omega t - \kappa Z)} \quad - (8)$$

provided that:

$$\kappa H^{(0)} = \omega D^{(0)} \quad - (9)$$

i.e.

$$\frac{B^{(0)}}{\mu} = \frac{\omega}{\kappa} \epsilon E^{(0)}. \quad - (10)$$

If

$$\epsilon_0 \mu_0 = \frac{1}{c^2} = \epsilon \mu \quad - (11)$$

eq. (10) becomes $E^{(0)} = c B^{(0)}$. $\quad - (12)$

3) Eq. (5) is:

$$\underline{\nabla} \times \left(\frac{\underline{B}}{\mu} \right) - \frac{\partial}{\partial t} \left(\epsilon \underline{E} \right) = \underline{0} \quad -(13)$$

(eq. (3.14) and eq. (3.15) of vol. 3, page 26).

If μ and ϵ are $\underline{r}$ and t independent then:

$$\underline{\nabla} \times \underline{B} - \epsilon \mu \frac{\partial \underline{E}}{\partial t} = \underline{0} \quad -(14)$$

where:

$$\epsilon \mu = \frac{1}{v^2} \quad -(15)$$

The solution of eq. (14) is the plane wave:

$$\underline{B} = \frac{B^{(0)}}{\sqrt{2}} \left(i \underline{i} + \underline{j} \right) e^{i\phi'} \quad -(16)$$

$$\underline{E} = \frac{E^{(0)}}{\sqrt{2}} \left(\underline{i} - i \underline{j} \right) e^{i\phi'} \quad -(17)$$

where

$$\phi' = \omega t - \kappa Z \quad -(18)$$

and

$$v = \frac{\omega}{\kappa} . \quad -(19)$$

The vacuum plane wave has:

$$\phi = \omega t - \kappa Z, \quad -(20)$$

$$\frac{\omega}{\kappa} = c \quad -(21)$$

4)

So the effect of the current $\underline{J}_{grav}$ in eq. (1) is to slow the propagation velocity from c to v. This is a refractive index effect equivalent to the bending of light by gravity.

The real part of eq. (17) is obtained from:

$$e^{i\phi'} = \cos\phi' + i\sin\phi' \quad -(22)$$

$$\underline{E} = \frac{E^{(0)}}{\sqrt{2}}(\underline{i} - i\underline{j})(\cos\phi' + i\sin\phi')$$

$$\mathrm{Re}(\underline{E}) = \frac{E^{(0)}}{\sqrt{2}}(\underline{i}\cos\phi' + \underline{j}\sin\phi') \quad -(23)$$

compared with the vacuum result:

$$\mathrm{Re}(\underline{E}) = \frac{E^{(0)}}{\sqrt{2}}(\underline{i}\cos\phi + \underline{j}\sin\phi) \quad -(24)$$

Using:

$$\left.\begin{aligned} \cos\phi' &= a\cos\phi \\ \sin\phi' &= b\sin\phi \end{aligned}\right\} \quad -(25)$$

eq. (23) is:

$$\mathrm{Re}(\underline{E}) = \frac{E^{(0)}}{\sqrt{2}}(a\,\underline{i}\cos\phi + b\,\underline{j}\sin\phi) \quad -(26)$$

The circularly polarized (24) has been changed to the elliptically polarized (26) by gravitation.