1) 93(7): Non-Zero Christoffel Symbols of a Spherically Symmetric Line Element without Torsion

These are:

$$\Gamma^0_{00} = \frac{1}{2} g^{00} \partial_0 g_{00} \quad \text{— (1)}$$

$$\Gamma^0_{01} = \frac{1}{2} g^{00} \partial_1 g_{00} \quad \text{— (2)}$$

$$\Gamma^1_{00} = -\frac{1}{2} g^{11} \partial_1 g_{00} \quad \text{— (3)}$$

$$\Gamma^0_{11} = -\frac{1}{2} g^{00} \partial_0 g_{11} \quad \text{— (4)}$$

$$\Gamma^1_{01} = \frac{1}{2} g^{11} \partial_0 g_{11} \quad \text{— (5)}$$

$$\Gamma^1_{11} = \frac{1}{2} g^{11} \partial_1 g_{11} \quad \text{— (6)}$$

$$\Gamma^2_{12} = \frac{1}{2} g^{22} \partial_1 g_{22} \quad \text{— (7)}$$

$$\Gamma^3_{13} = \frac{1}{2} g^{33} \partial_1 g_{33} \quad \text{— (8)}$$

$$\Gamma^1_{22} = -\frac{1}{2} g^{11} \partial_1 g_{22} \quad \text{— (9)}$$

$$\Gamma^1_{33} = \frac{1}{2} g^{11} \partial_1 g_{33} \quad \text{— (10)}$$

$$\Gamma^2_{33} = -\frac{1}{2} g^{22} \partial_2 g_{33} \quad \text{— (11)}$$

$$\Gamma^3_{23} = \frac{1}{2} g^{33} \partial_2 g_{33} \quad \text{— (12)}$$

— (13)

where:

$$g_{00} = -\left(1 - \frac{2mG}{rc^2}\right), \quad g_{11} = \left(1 - \frac{2mG}{rc^2}\right)^{-1}, \quad g_{22} = r^2, \quad g_{33} = r^2 \sin^2\theta$$

$$g^{00} = g_{00}^{-1}, \quad g^{11} = g_{11}^{-1}, \quad g^{22} = g_{22}^{-1}, \quad g^{33} = g_{33}^{-1}$$

— (14)

2)

We have:

$$g = -c^2 \Gamma^1_{00} = -\frac{MG}{r^2}\left(1 - \frac{2MG}{rc^2}\right) \quad -(15)$$

$$\Rightarrow F = mg = -\frac{mMG}{r^2} \quad -(16)$$

if

$$2MG << rc^2. \quad -(17)$$

It is important to note that <u>none</u> of ~~these~~ <u>the Cartan relations are true</u> in <u>the presence</u> of <u>torsion</u>:

$$T^{\kappa}_{\mu\nu} = \Gamma^{\kappa}_{\mu\nu} - \Gamma^{\kappa}_{\nu\mu} \neq 0. \quad -(18)$$

Eq. (15) is <u>alone</u> sufficient to calculate the light deflection <u>too</u> due to gravity in g.r., and also the perihelia advance and gravitational red-shift. However, in the presence of Cartan torsion the relation between the metric and Christoffel symbol can no longer be used, because it depends on the assumption that:

$$\left.\begin{aligned} g_{\mu\nu} &= g_{\nu\mu} \\ \Gamma^{\kappa}_{\mu\nu} &= \Gamma^{\kappa}_{\nu\mu} \end{aligned}\right\} \quad -(19)$$

The light deflection due to gravity in the <u>absence</u> of <u>torsion</u> is given by:

3)

$$\delta = \frac{4MG}{r_0 c^2} \quad -(20)$$

where r_0 is the distance of closest approach. This is the most famous result of g.r. It is however changed by torsion. Eq (20) is calculated using:

$$T^{\kappa}_{\mu\nu} = 0 \quad -(21)$$

and this is not true in general in differential geometry. Indeed, we have seen that galaxies are dominated by torsion. Result (20) is true in the solar system to 1 : 100,000 because the torsion is small in the solar system.

To evaluate the various effects of torsion to curvature interaction on light grazing a massive object it is more instructive to use the ECE field equations than to try to correct the EH field equations. This is because the latter are field equations. This is because the latter are a limit of a restricted geometry:

$$\left.\begin{array}{l} R \wedge q = 0 \\ D \wedge R = 0 \end{array}\right\} -(22)$$

whereas the correct geometry (paper 88) is:

$$\boxed{D \wedge T := R \wedge q \neq 0} -(23)$$

4) As in paper 67, the current geometry (23)
gives:

$$\underline{\nabla} \times \left(n \, \underline{E}^a \right) + \frac{\partial}{\partial t} \left(\frac{\underline{B}^a}{n} \right) = \underline{0} \quad -(24)$$

where the refractive index is:

$$n^2 = \frac{c}{v} \quad -(25)$$

The plane wave solution of eq. (24) is:

$$\underline{E}_1 = \frac{E^{(0)}}{\sqrt{2}} \left(\underline{i} - i \underline{j} \right) \exp(i \phi_1) \quad -(26)$$

$$\underline{B}_1 = \frac{B^{(0)}}{\sqrt{2}} \left(i \underline{i} + \underline{j} \right) \exp(i \phi_1) \quad -(27)$$

$$\phi_1 = \frac{\omega}{n} t - n \kappa Z, \quad -(28)$$

$$\underline{E}_1 = n \underline{E}, \quad \underline{B}_1 = \frac{1}{n} \underline{B}. \quad -(29)$$

Thus:

$$\underline{E}_1 = \frac{E^{(0)}}{\sqrt{2}} \left(a \, \underline{i} \cos \phi + b \, \underline{j} \sin \phi \right) \quad -(30)$$

This means that the plane of polarization of light is changed by mass. This phenomenon is caused by the current:

$$j = \frac{A^{(0)}}{\mu_0} \left(R \wedge q - \omega \wedge T \right) \quad -(31)$$

5) i.e. by the correct geometry (23). The parameters a and b are complicated to calculate but can be fixed by observation. It is known that mass does actually change the polarization of light, thus experimentally verifying ECE ~~gravitational~~ ~~theory~~.

To proceed, it is possible to develop the phenomenon of light deflection by gravity in terms of the refractive index n, using eqs. (24) to (30), firstly for the solar system, and ~~then~~ for the general case (31). In the solar system:

$$R \wedge q = 0, \quad T = 0 \qquad -(32)$$

so:

$$j = 0, \qquad -(33)$$

so:

$$n = 1. \qquad -(34)$$

In the presence of torsion:

$$R \wedge q \neq 0, \quad T \neq 0, \qquad -(35)$$

so:

$$j \neq 0, \qquad -(36)$$

and

$$n \neq 1. \qquad -(37)$$

So it is clear that torsion will change the

b) angle of deflection from the result given by eq. (20). Therefore the observation of polarization changes in light grazing very heavy objects means that there is interaction between torsion and curvature such that:

$$j \neq 0 \quad — (38)$$

The Einstein Hilbert theory of eqs (1) to (14) is purely kinematic, it is based on a null geodesic and contains no mention of the Maxwell Heaviside theory. In the latter, there is no light deflection due to gravity. In ECE theory both the kinematic and electrodynamical properties of light are changed due to gravity, both in the presence and absence of torsion.

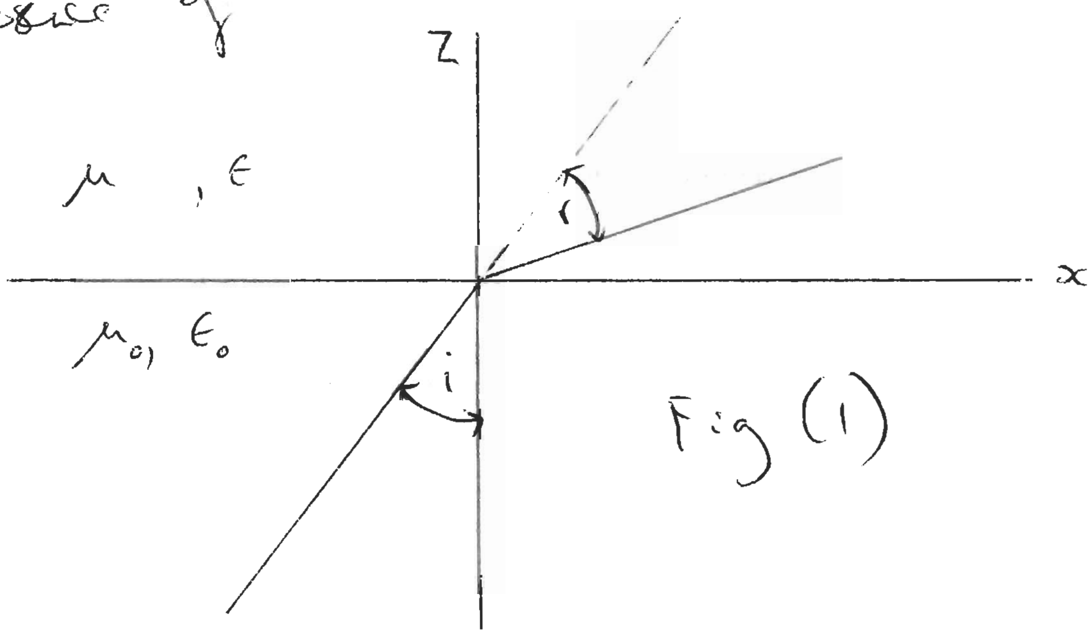

Fig (1)

The general case of refraction is given in Fig (1). In this case

7) $n = \left(\frac{\mu \epsilon}{\mu_0 \epsilon_0}\right)^{1/2}, \quad n' = \left(\frac{\mu' \epsilon'}{\mu_0 \epsilon_0}\right)^{1/2}$ — (39)

and by Snell's law:

$$\frac{\sin i}{\sin r} = \frac{n'}{n} \quad -(40)$$

If we take the special case of:

$$i = 90^\circ, \quad \sin r = \frac{n}{n'}, \quad \mu' \epsilon' = \mu_0 \epsilon_0 \quad -(41)$$

then

$$\boxed{n' = \sin^{-1} r} \quad -(42)$$

In the solar system:

$$r = \frac{4MG}{r_0 c^2} \quad -(43)$$

$$\boxed{n' = \sin^{-1}\left(\frac{4MG}{r_0 c^2}\right)} \quad -(44)$$

The ECE equations for this phenomena are:

$$d \wedge F^a = 0 \quad -(45)$$

$$d \wedge \tilde{F}^a = \frac{\mu_0}{A^{(0)}} \tilde{R} \wedge q \quad -(46)$$

where $\tilde{R} \wedge q \neq 0$ is due to the sun. Torsion would change eqns. (45) and (46) to:

8)

$$d \wedge F^a = \mu_0 \left(R \wedge q - \omega \wedge T \right) \quad -(47)$$

$$d \wedge \tilde{F}^a = \mu_0 \left(\tilde{R} \wedge q - \omega \wedge \tilde{T} \right) \quad -(48)$$

Eq. (24) is another form of eq. (47) and it is seen ~~that~~ torsion would produce changes in n of eq. (44), and changes in polarization of light grazing the sun.