319(3): Development of Note 319(2)

The force in ECE2 is defined by:

$$\underline{F} = m\underline{g} = -\underline{\nabla} U - \frac{\partial \underline{p}}{\partial t} - 2U\underline{\omega} + 2c\omega_0 \underline{p} \quad -(1)$$

with antisymmetry law:

$$-\underline{\nabla} U - 2U\underline{\omega} = -\frac{\partial \underline{p}}{\partial t} + 2c\omega_0 \underline{p} \quad -(2)$$

So:

$$\underline{F} = 2\left(-\underline{\nabla} U - 2U\underline{\omega}\right) = 2\left(-\frac{\partial \underline{p}}{\partial t} + 2c\omega_0 \underline{p}\right) \quad -(3)$$

The Newtonian theory is classical, so it is not relativistic and there is no spin connection. So the Newtonian theory can be thought of as the limit

$$\underline{\nabla} U = \frac{\partial \underline{p}}{\partial t} \quad -(4)$$

Eq. (4) is the Newtonian equivalence principle:

$$\underline{F} = m\underline{g} = -\frac{mMG}{r^2}\underline{e}_r \quad -(5)$$

$$= -\frac{\partial \underline{p}}{\partial t}$$

Possible solutions of eq. (3) are:

2)

$$\frac{\partial \underline{p}}{\partial t} = 2 U \underline{\omega} \quad -(6)$$

and

$$\underline{\nabla} U = -2 c \omega_0 \underline{p} \quad -(7)$$

With the assumptions (6) and (7):

$$\underline{F} = 2\left(-\underline{\nabla} U - \frac{\partial \underline{p}}{\partial t}\right) = 2\left(-2U\underline{\omega} + 2c\omega_0 \underline{p}\right)$$

$$= m \underline{g} \quad -(8)$$

This is eq. (7) of Note 319(2), <u>Q.E.D.</u>

If it is assumed in eq. (3) that:

$$\underline{\nabla} U = 2 U \underline{\omega} \quad -(9)$$

and

$$-\frac{\partial \underline{p}}{\partial t} = 2 c \omega_0 \underline{p} \quad -(10)$$

it follows that:

$$\underline{\nabla} U = \frac{\partial \underline{p}}{\partial t} \quad -(11)$$

so a Newtonian-like equivalence principle can be derived from conditions (9) and (10). <u>Eq. (11)</u> is <u>however</u> an <u>equivalence principle of generally covariant unified field theory</u> under the <u>assumptions (9) and (10).</u>

It follows that the most general equivalence principle is the antisymmetry equation (3). This finding leads to a generalization of the other equivalence principles of physics.

The solutions of eqns. (9) and (10) can be written as:

$$\underline{\nabla} = 2\underline{\omega} \quad -(12)$$

and

$$\frac{1}{c}\frac{\partial}{\partial t} = -2\omega_0 \quad -(13)$$

i.e.

$$\partial_\mu = \left(\frac{1}{c}\frac{\partial}{\partial t}, \underline{\nabla}\right) = -2\omega_\mu = -2\left(\omega_0, -\underline{\omega}\right) \quad -(14)$$

Therefore under the condition:

$$\boxed{\omega_\mu = -\frac{1}{2}\partial_\mu} \quad -(15)$$

The most general equivalence principle reduces to eq. (11), i.e. to an Newtonian-like result but part of a generally covariant unified field theory. Conversely this indicates that the Newtonian equivalence principle is a manifestation of the more general result (3) under the condition (15).

4) The general equivalence principle (3) means that gravitational forces vanish when:

$$\boxed{-\underline{\nabla}\Phi - 2\Phi\,\underline{\omega} = -\frac{\partial \underline{p}}{\partial t} + 2c\omega_0\,\underline{p} = \underline{0}} \quad -(16)$$

Eq. (16) means:

$$\underline{\nabla}\Phi = -2\Phi\,\underline{\omega} \quad -(17)$$

and

$$\frac{\partial \underline{p}}{\partial t} = 2c\omega_0\,\underline{p} \quad -(18)$$

i.e.

$$\boxed{\omega_\mu = \frac{1}{2}\partial_\mu} \quad -(19)$$

This is the opposite condition to eq. (15).

The basic gravitational field equations of ECE2 are:

$$\underline{\nabla}\cdot\underline{\Omega} = 0 \quad -(16)$$

$$\underline{\nabla}\times\underline{g} + \frac{\partial \underline{\Omega}}{\partial t} = \underline{0} \quad -(17)$$

$$\underline{\nabla}\cdot\underline{g} = \underline{\kappa}\cdot\underline{g} = 4\pi G\rho_m \quad -(18)$$

$$\underline{\nabla}\times\underline{\Omega} - \frac{1}{c^2}\frac{\partial \underline{g}}{\partial t} = \frac{4\pi G}{c^2}\underline{J}_m = \underline{\kappa}\times\underline{\Omega} \quad -(19)$$

These field equations have a Lorentz-like

5) covariance but are equations of a generally covariant unified field theory (ECE2).

This means that they can be written in a Minkowski-like metric, always bearing in mind that they are equations in the general metric.

This realization links ECE2 to x theory, and is a link to papers such as UFT 216 and UFT 261, and the development of orbital theory with a Minkowski-like metric. The velocity from a Minkowski-like metric is

$$v^2 = \left(\frac{dr}{dt}\right)^2 + r^2\left(\frac{d\theta}{dt}\right)^2 \quad -(20)$$

for a planar orbit. For an observed orbit of type:

$$r = \frac{\alpha}{1 + \epsilon\cos(x\theta)} \quad -(21)$$

of x theory the deflection of light due to gravitation is obtained from the velocity from eqs. (20) to (21):

$$v^2 = \frac{L^2}{R_0 m^2}\left[\frac{x^2}{\alpha}(1+\epsilon) - \frac{1}{R_0}(x^2-1)\right] \quad -(22)$$

In the Newtonian limit:

6)

$$x = 1 \quad -(23)$$

So

$$v^2 = \frac{L^2 (1+\epsilon)}{R_0 m^2 \alpha} \quad -(24)$$

where R_0 is the distance of closest approach.
The limit (24) should be regarded as the limit of a generally covariant unified field theory where:

$$r = \frac{\alpha}{1+\epsilon\cos\theta} \quad -(25)$$

which is the conical section of Newtonian theory.
Light deflection by the sun is described by the hyperbola:

$$\epsilon > 1. \quad -(26)$$

In this limit,

$$L^2 = M m^2 G \alpha \quad -(27)$$

so

$$v^2 = \frac{MG}{R_0^2} \quad -(28)$$

where

$$R_0 = \frac{\alpha}{1+\epsilon} \quad -(29)$$

In this limit the angle of deflection is:

$$2\phi = \frac{2}{\epsilon} = 2\left(\frac{R_0 v^2}{MG} - 1\right)^{-1}$$

$$\sim \frac{2MG}{R_0 v^2} \quad -(30)$$

7) The experimentally observed result is:

$$2\phi = \frac{4MG}{R_0 c^2} \quad - (31)$$

This result can be expressed as:

$$2\phi = -\frac{\Phi}{c^2} \quad - (31)$$

where

$$\Phi = -\frac{4MG}{R_0} \quad - (32)$$

Eq. (30) is obtained as the limit of a more general expression:

$$2\phi = \frac{2}{\epsilon} = 2\left[\frac{n^2 \alpha R_0}{x^2 L^2}\left(v^2 + \frac{L^2}{n^2}\left(\frac{1-x^2}{R_0^2}\right)\right) - 1\right]^{-1} \quad - (33)$$

corresponding to

$$r = \frac{\alpha}{1+\epsilon\cos(x\theta)} \quad - (34)$$

So the experimental result is obtained from:

$$\left(\frac{v^2}{x^2} + \frac{L^2}{n^2 R_0^2}\frac{(1-x^2)}{x^2}\right)^{-1} = \frac{2}{c^2} \quad - (35)$$

This equation defines a Lorentz factor of

) the Lorentz - like eqs (16) to (19).

So
$$v^2 + v_1^2 = \frac{x c^2}{2} \quad -(36)$$
where
$$v_1^2 = \frac{L^2 (1 - x^2)}{m^2 R_0^2} \quad -(37)$$
To an excellent approximation:
$$x \sim 1 \quad -(38)$$
So
$$\boxed{c^2 = 2v^2} \quad -(39)$$
This is the condition needed for:
$$2\phi = \frac{4MG}{R_0 c^2} = \frac{2MG}{R_0 v^2} \quad -(40)$$
