318(2): Antisymmetry, Equivalence Principles and Electromagnetic Effects in ECE2.

The relevant equations are:

$$\underline{\nabla} \cdot \underline{E} = \underline{\kappa} \cdot \underline{E} = \rho / \epsilon_0 \quad -(1)$$

and

$$\underline{\nabla} \cdot \underline{g} = 4\pi G \rho_m \quad -(2)$$
$$= \underline{\kappa} \cdot \underline{g}$$

in previous notation.

The field potential relations are:

$$\underline{E} = -\underline{\nabla}\phi - \frac{\partial \underline{A}}{\partial t} + 2\left(c\omega_0 \underline{A} - \phi \underline{\omega}\right) \quad -(3)$$

and

$$\underline{g} = -\underline{\nabla}\Phi - \frac{\partial \underline{Q}}{\partial t} + 2\left(c\omega_0 \underline{Q} - \Phi \underline{\omega}\right) \quad -(4)$$

Antisymmetry Laws

These are:

$$-\underline{\nabla}\phi + 2c\omega_0 \underline{A} = \frac{\partial \underline{A}}{\partial t} + 2\phi \underline{\omega} \quad -(5)$$

and

$$-\underline{\nabla}\Phi + 2c\omega_0 \underline{Q} = \frac{\partial \underline{Q}}{\partial t} + 2\Phi \underline{\omega} \quad -(6)$$

In the absence of a magnetic potential $\underline{A}$ and gravitomagnetic potential $\underline{Q}$:

2)

$$\underline{E} = -\underline{\nabla}\phi = 2\phi\,\underline{\omega} \quad -(7)$$

and

$$\underline{g} = -\underline{\nabla}\,\underline{\Phi} = 2\underline{\Phi}\,\underline{\omega} \quad -(8)$$

Eqs. (7) and (8) are the classical equivalence principles of Newtonian gravitation and electrostatics. So the equivalence principles are given immediately by antisymmetry.

Multiplying both sides of eq. (8) by a test mass m gives:

$$\underline{F} = m\underline{g} = -m\underline{\nabla}\,\underline{\Phi} = 2m\underline{\Phi}\,\underline{\omega} \quad -(9)$$

In classical dynamics:

$$\underline{\Phi} = \frac{MG}{r} \quad -(10)$$

where M is the mass of an object that attracts m. So we obtain the Newtonian equivalence principle:

$$\underline{F} = m\underline{g} = -\frac{mMG}{r^2}\underline{e}_r = \frac{2mMG}{r}\underline{\omega} \quad -(10)$$

with

$$\underline{\omega} = -\frac{1}{r}\underline{e}_r \quad -(11)$$

) In classical electrodynamics in the limit of electrostatics:

$$\underline{F} = e\underline{E} = -e\underline{\nabla}\phi = 2e\phi\underline{\omega} \quad -(12)$$

In classical electrostatics:

$$\phi = \frac{e_1}{4\pi\epsilon_0 r} \quad -(13)$$

so

$$\underline{F} = e\underline{E} = -\frac{e e_1}{4\pi\epsilon_0 r^2}\underline{e}_r = 2\frac{e_1}{4\pi\epsilon_0 r}\underline{\omega} \quad -(14)$$

So

$$\underline{\omega} = -\frac{1}{2r}\underline{e}_r \quad -(15)$$

Self for Newtonian attraction and electrostatics.

In terms of magnitude:

$$g = 2\Phi\omega \quad -(16)$$

$$E = 2\phi\omega \quad -(17)$$

So

$$\boxed{\underline{g} = \left(4\pi\epsilon_0 G\frac{M}{e}\right)\underline{E}} \quad -(18)$$

where:

$$G = (6.6726 \pm 0.0005) \times 10^{-11}\ N m^2 kg^{-2}$$

$$\epsilon_0 = 8.854188 \times 10^{-12}\ J^{-1} C^2 m^{-1}$$

$$4\pi\epsilon_0 = 1.112650 \times 10^{-10}\ J^{-1} C^2 m^{-1}$$

It follows that:

4)

$$\underline{g} = 9.851612 \times 10^{-22} \frac{M}{e} \underline{E} \quad -(19)$$

This means that the acceleration due to gravity $\underline{g}$ can be expressed in terms of an electric field strength $\underline{E}$ in volts m^{-1}. At sea level the standard acceleration due to gravity is:

$$g = 9.80665 \, m s^{-2} \quad -(20)$$

and the mass of the earth is:

$$\underline{M} = 5.972 \times 10^{24} \, kg \quad -(21)$$

The acceleration due to gravity is defined by:

$$g = -\frac{MG}{r^2} = -\frac{e}{4\pi\epsilon_0 r^2} \quad -(22)$$

where r is the radius of the earth:

$$r = 6371 \, km = 6.371 \times 10^6 \, m \quad -(23)$$

In the laboratory however, considering a mass $\underline{M}$ of one kilogram charged by one coulomb:

$$\underline{g} = 9.851612 \times 10^{-22} \underline{E} \quad -(24)$$

The total force present is:

$$\underline{F} = 2(m\Phi + e\phi)\underline{\omega} \quad -(25)$$

$$= \underline{F_1} + \underline{F_2}$$

5)

and in the standard model it is assumed that there is an attraction between two masses, and an attraction or repulsion between two charges. It is assumed that there is no interaction between charge and mass. In order for such an interaction to exist eq. (25) would have to be:

$$\underline{F} = \underline{F_1} + \underline{F_2} + \underline{F_{12}} \quad -(26)$$

where $\underline{F}_{12}$ allows interaction between charge and mass. This means that $\underline{E}$ could be expressed in terms of Φ and $\underline{Q}$, and $\underline{g}$ could be expressed in terms of ϕ and $\underline{A}$.

Finally consider eq. (1):

$$\underline{\nabla} \cdot \underline{E} = \underline{\kappa} \cdot \underline{E} = \rho / \epsilon_0 \quad -(27)$$

with the acceleration due to gravity:

$$\underline{g} = g_r \, \underline{e}_r = -\frac{MG}{r^2} \, \underline{e}_r \quad -(28)$$

Then:

$$\frac{\partial g_r}{\partial r} = \frac{2MG}{r^3} = 2 g_r \left(\frac{1}{r^{(0)}} q_r - \omega_r \right) \quad -(29)$$

$$= -\frac{2MG}{r^2} \left(\frac{1}{r^{(0)}} q_r - \omega_r \right)$$

So:

$$\omega_r - \frac{1}{r^{(0)}} q_r = \frac{1}{r} \quad -(30)$$

From eq. (15):

$$\omega_r = -\frac{1}{2r} \quad -(31)$$

so

$$\frac{1}{r^{(0)}} q_r = -\frac{3}{2r} \quad -(32)$$

The radial tetrad component is therefore:

$$\boxed{q_r = -\frac{3}{2}\frac{r^{(0)}}{r}} \quad -(33)$$

and the radial spin connection is:

$$\boxed{\omega_r = -\frac{1}{2r}} \quad -(34)$$

where:

$$r^{(0)} = \frac{W^{(0)}}{A^{(0)}} \quad -(35)$$
