318(5): Vacuum and Aharonov Bohm Effects in ECE2

These are defined by:

$$\underline{E} = -\underline{\nabla}\phi - \frac{\partial \underline{A}}{\partial t} + 2(c\omega_0\underline{A} - \phi\underline{\omega}) = \underline{0} \quad -(1)$$

$$\underline{B} = \underline{\nabla}\times\underline{A} + 2\underline{\omega}\times\underline{A} = \underline{0} \quad -(2)$$

Therefore in ECE2, $\phi$ and $\underline{A}$ are non-zero when $\underline{E}$ and $\underline{B}$ are zero. This means that potentials exist in the absence of fields. These are known as the vacuum potentials and are responsible for energy from spacetime.

By antisymmetry:

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

It follows that the vacuum potentials are defined by:

$$-\underline{\nabla}\phi + 2c\omega_0\underline{A} = \underline{0} \quad -(4)$$

$$-\frac{\partial \underline{A}}{\partial t} - 2\phi\underline{\omega} = \underline{0} \quad -(5)$$

$$\underline{\nabla}\times\underline{A} + 2\underline{\omega}\times\underline{A} = \underline{0} \quad -(6)$$

If it is assumed for the sake of simplicity that:

$$\omega_0 = 0 \quad -(7)$$

then there are three equations in three unknowns:

$$\underline{\nabla}\,\phi = \underline{0} \quad -(8)$$

$$\frac{\partial \underline{A}}{\partial t} + 2\phi\,\underline{\omega} = \underline{0} \quad -(9)$$

$$\underline{\nabla} \times \underline{A} + 2\underline{\omega} \times \underline{A} = \underline{0} \quad -(10)$$

<u>Therefore</u> $\phi$, $\underline{A}$ <u>and</u> $\underline{\omega}$ <u>can be found.</u>

The energy momentum contained in the vacuum is:

$$E^\mu = \left(\frac{E}{c}, \underline{p}\right) \quad -(11)$$

$$= e\left(\frac{\phi}{c}, \underline{A}\right) \quad -(12)$$

So the energy momentum of the vacuum is:

$$\boxed{E^\mu = eA^\mu} \quad -(13)$$

The ECE2 vacuum can be thought of as being made of photons with energy momentum:

$$E^\mu = \hbar\left(\frac{\omega}{c}, \underline{\kappa}\right) = eA^\mu \quad -(14)$$

3) The vacuum Einstein / de Broglie equations mean that:

$$E = e\phi = \hbar\omega = \gamma m c^2 \quad -(15)$$

and

$$\underline{p} = e\underline{A} = \hbar\underline{\kappa} = \gamma m \underline{v} \quad -(16)$$

where $m$ is the photon mass and:

$$\gamma = \left(1 - \frac{v^2}{c^2}\right)^{-1/2} \quad -(17)$$

The fermion equation can be used to describe the interaction of one electron with the ECE2 vacuum defined by Eqs. (4) to (6). The interaction of the ECE2 vacuum with one electron is the simplest model of a circuit taking energy from spacetime represented by the ECE2 vacuum.

Similarly there are gravitational AB effects which are described in the next note.