SOME NOTES ON "ASYMMETRIC REGAUGING"

We define "asymmetric regauging" as a violation of the Lorenz condition in the vacuum. This leads to a vacuum current, vacuum polarization, and to the structure of the O(3) field equations and Lehnert field equations.

Violation of the Lorenz Condition in U(1) (S.I. Units)

Start with:

$$A^{\mu} \equiv (\phi, c\boldsymbol{A}) \tag{1}$$

$$\nabla \times \boldsymbol{E} + \frac{\partial \boldsymbol{B}}{\partial t} = \boldsymbol{0}; \qquad \nabla \times \boldsymbol{B} - \frac{1}{c^2}\frac{\partial \boldsymbol{E}}{\partial t} = \boldsymbol{0} \tag{2}$$

$$\boldsymbol{B} = \nabla \times \boldsymbol{A}; \qquad \boldsymbol{E} = -\frac{\partial \boldsymbol{A}}{\partial t} - \nabla\phi \tag{3}$$

$$\Rightarrow \quad \Box \boldsymbol{A} = -\nabla\left(\nabla \cdot \boldsymbol{A} + \frac{1}{c^2}\frac{\partial \phi}{\partial t}\right) \equiv \mu_0 \boldsymbol{j}_A \tag{4}$$

where $\boldsymbol{j}_A$ is a **vacuum current**. This is **gauge invariant and physical. Therefore, current comes from the vacuum**. This is analogous to the idea behind Maxwell's displacement current, and is precisely the result obtained by the phenomenological introduction of vacuum current by Lehnert:

$$j_A^{\mu} = (0, \boldsymbol{j}_A) \tag{5}$$

$$\boldsymbol{j}_A = \sigma\, \boldsymbol{E}_A \tag{6}$$

Eqn. (6) is eqn. (2.18) of Lehnert and Roy, "Extended Electromagnetic Theory", World Scientific, 1998). It is shown by Lehnert and Roy that the **vacuum** Maxwell equations then become:

$$\begin{aligned} \nabla \cdot \boldsymbol{E} &= 0; \qquad & \nabla \times \boldsymbol{H} &= \sigma\, \boldsymbol{E}_A + \frac{\partial \boldsymbol{D}}{\partial t} \\ \nabla \cdot \boldsymbol{H} &= 0; \qquad & \nabla \times \boldsymbol{E} + \frac{\partial \boldsymbol{B}}{\partial t} &= \boldsymbol{0} \end{aligned} \tag{7}$$

If we use:

$$\boldsymbol{B} = \mu_0 \boldsymbol{H}; \qquad \boldsymbol{D} = \varepsilon_0 \boldsymbol{E} + \boldsymbol{P}_A \tag{8}$$

where $\boldsymbol{P}_A$ is a **vacuum polarization**, then a comparison of eqns. (2), (3) and (7) gives:

$$\boxed{\frac{\partial \boldsymbol{P}_A}{\partial t} = -\boldsymbol{j}_A} \tag{9}$$

There is a time dependent vacuum polarization whose magnitude depends on the vacuum current j_A, **or the extent of the asymmetric regauging**. The concept of vacuum polarization is already present in quantum electrodynamics, but is removed in classical electrodynamics by the Lorenz condition.

O(3) Electrodynamics

The appropriate equation in O(3) electrodynamics is (Evans & Crowell, World Scientific, 1999):

$$\nabla \times \boldsymbol{H}^{(i)} = \frac{\partial \boldsymbol{D}^{(i)}}{\partial t} + \boldsymbol{J}^{(i)}; \quad i = 1, 2, 3 \tag{10}$$

The $\boldsymbol{J}^{(i)}$ current if O(3) electrodynamics in the vacuum is exactly that obtained by breaking the Lorenz condition in the vacuum on the U(1) level.

CONCLUSION

Both current and charge can be obtained from the topology of the vacuum. This has been proven experimentally with a number of working devices. This result is a natural consequence of O(3) electrodynamics which gives Lehnert electrodynamics as a special case.