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Dummy Waves

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The idea to transform the optional Lorenz gauge equation that we impose on the electromagnetic potential,

$$A^k{}_{|k} = 0 \tag{1}$$

into a mandatory physical requirement under the name “potential conservation” makes the potential unique. Now the potential perceived is not just as mathematical tool but has a physical meaning by itself (besides the physical meaning of the electromagnetic field,

$$F_{ik} = A_{k|i} - A_{i|k} \tag{2}$$

that is produced by the said potential). It is a known fact that only on condition (1) does the potential satisfy the field equations:

$$\Box A^k = -\frac{4\pi}{c} j^k \tag{3}$$

The general solution of the equation (3) is:

$$A^k(t,\vec{x}) = \int_{r'\le a} j^k(t-r',\vec{r}\,')r'dr'd\Omega' + \frac{1}{4\pi}\int_{r'=a;\,t'=t-a} \left(A^k + r'A^k{}_{|r'} + r'A^k{}_{|t'}\right)d\Omega' \tag{4}$$

where the coordinates of integration (indicated by primes) are chosen to be spherical and centered on the point of observation (t,x). The region of integration is the ball and sphere centered at the point of observation . The first integral is a retarded volume integral and the second integral is a retarded sphere integral. The advance solutions are not written because the use of them gives the same result (see my www.clssed.us/Ret_Adv/Ret_Adv.htm). Formula (4) is not convenient when it comes to finding derivatives because the regions of integration are chosen as connected to the point of observation. One has to understand that given the incoming wave at infinity in the past and the currents in our experimental arrangement produce the unique potential.

Dummy Plane Wave

Let us choose the potential equal to a gradient of some function G:

$$A_k = G_{|k}; \quad F_{ik} = 0; \quad A^k{}_{|k} = G^{|k}{}_{|k} = -\Box G = 0 \tag{5}$$

We see that there is no electromagnetic field that corresponds to this potential and the function G has to satisfy to the homogeneous wave equation as a result of (1). We call the function G “Dummy

Generator" and the corresponding potential, "Dummy Wave". In the simplest case of plane wave symmetry we can write:

$$G^{\pm} = e^{\mp ikz + i\omega t}; \quad \Phi = \frac{\omega}{c} G^{\pm}; \quad A^{z} = \pm ikG^{\pm} \tag{6}$$

Does a dummy wave exist? And if so how to detect it? How to generate it? According to (4), if there is no incoming waves and no currents then the potential is zero. If we introduce currents then the electromagnetic waves and the dummy waves are possible. All depends on currents. What quality of currents will be responsible for the presence of dummy waves? All currents satisfy the conservation equation (like (1)). It can be shown that if the current vector itself is a gradient of some "generator of current" function that also satisfies the homogeneous wave equation, then the corresponding potential will be a dummy wave. Well, in all the macroscopic experiments of CED, the carrier of current is an elementary particle (electron is most common). The correct representation of a point charged particle is:

$$j^{k} = e\dot{x}^{k}(t)\delta(x^{1} - x^{1}(t))\delta(x^{2} - x^{2}(t))\delta(x^{3} - x^{3}(t)) \tag{7}$$

where $x^k(t)$ is the given trajectory of a point particle and t is a parameter (the most convenient parameter is time x^0=ct). The singular current density (7) satisfies the conservation of current equation but it can not be represented as a gradient of yet another function. That gives us an explanation for why we do not have dummy waves in a macroscopic physical experiment.

Let us go inside an elementary particle where the current density can be a continuous nonsingular field. Here it is possible that a current density can be represented as a gradient of yet another function that has to be the solution of a homogeneous wave equation (since the currents have to satisfy the conservation). We are coming to a very interesting conclusion:

An elementary particle can generate continuously, spherical outgoing dummy waves since the energy of dummy waves is zero.

References:

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