Absorption by Non-Radiating Systems

A possible way to generate low frequency components in UWB fields

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Abstract— **The radiation energy lost by absorption is not always taken into account by superposition of the fields, rendering necessary a deflation or inflation of the incident field. Deflation / inflation of radiation fields can be described only by modified Maxwell equations. By phase-locked deflation / inflation of UWB fields it might be possible to generate low frequency components. Such fields would enable the stimulation of neurons in a better focused way than by using near fields.**

Keywords - absorption, divergence, modified Maxwell equations, UWB, low frequency component, neural stimulation

I. A Case Not Covered By Classical Theory

As a consequence of the two Maxwell equations related to divergence, radiation fields cannot be multiplicatively attenuated. Proofs that non-radiating systems cannot absorb energy are based on this fact. The goal of this paper is to provide a counter-example in form of a simple thought experiment:

A non-conducting, evenly charged spherical shell which oscillates radially does not radiate. Since the power radiated by a charge is the same in all inertial frames the shell remains non-radiating as long as its center moves without acceleration. The center of a nearly harmonically oscillating shell moves uniformly along the axis of a radially polarized monochromatic beam of the same frequency. Suppose the profile of the longitudinal E component of the beam has a flat top. Then the field components of the beam exchange energy with the charged sphere as follows (subscripts L and R refer to longitudinal resp. radial components):

Seen from the rest frame of the shell, $P_{ER} = P_{BR} = P_R = 0$. Since the power gained or lost by the oscillation has to be independent of the frame, this is true in every inertial frame. Due to the oscillation, $F_{BL} \neq 0$. Thus in this frame, conservation of momentum is violated. Seen from the rest frame of the focus, generally $P_{ER} \neq 0$ => $P_{BR} \neq 0$. Since always $P_{BL} + P_{BR} = 0$ => $P_{BL} \neq 0$. If the sphere remains inside the flat portion of the beam profile $F_{EL} \approx 0$ => $P_{EL} \approx 0$ => $P_L \neq 0$. In this frame, energy and momentum are not conserved. Introducing deflation of the beam, F_L becomes radiation pressure and P_L becomes the absorbed power. Magnitude and direction of the power flow depend on the phase relation of oscillation and beam, of course.

All details of this thought experiment including numerical examples will be published in the full presentation, of course. Please note that the equations employed to model the beam are exact solutions of the Maxwell equations [1]. The described effect does neither depend on quantization nor on extremely strong fields but belongs to the domain of classical theory.

II. Adapting The Maxwell Equations

In order to enable the deflation or inflation of radiation fields some kind of "free" (i.e. not bound to particles) divergence has to be introduced. The density of this divergence is termed ς_e for the electric field and ς_m for the magnetic field. Due to geometry, the divergence is accompanied by a curl of the magnetic resp. electric field. Therefore, a virtual velocity (as if the fields were moving) is assigned to the divergence in such a way as to yield the continuity equations

$$\nabla \cdot \mathbf{J}_{\varsigma e} = -\partial \varsigma_e / \partial t \quad \text{and} \quad \nabla \cdot \mathbf{J}_{\varsigma m} = -\partial \varsigma_m / \partial t$$

with the current densities $\mathbf{J}_{\varsigma e}$ and $\mathbf{J}_{\varsigma m}$. The modified Maxwell equations thus read

$$\nabla \times \mathbf{E} = -\dot{\mathbf{B}} - \mathbf{J}_{\varsigma m} \tag{1}$$

$$\nabla \times \mathbf{H} = \dot{\mathbf{D}} + \mathbf{J}_{\mathbf{e}} \tag{2}$$

$$\nabla \cdot \mathbf{D} = \rho_e + \varsigma_e \tag{3}$$

$$\nabla \cdot \mathbf{B} = \varsigma_m \tag{4}$$

with $\mathbf{J}_{\mathbf{e}} = \mathbf{J}_{\rho e} + \mathbf{J}_{\varsigma e}$. Of course, parts of the theory have to be adapted resp. complemented (e.g. $\mathbf{B}$ has to be determined by a vector potential <u>and</u> a scalar potential; the spatial distribution of ς_e and ς_m has to be determined).

III. Verification And Application

Directly measuring the divergence or proving the existence of $\mathbf{J}_{\varsigma m}$ by measuring $\nabla \times \mathbf{E}$ during absorption of a monochromatic radiation field seems not to be feasable. An interesting question is whether it is possible to generate a low frequency component in UWB radiation by deflating or inflating half cycle pulses depending on their polarity. To look beyond classical theory: Chopping photons mechanically is known to broaden their spectrum [2]; multiplicatively modulating might as well generate frequency components far below the initial spectrum of polychromatic photons. If so, the LF component in $\nabla \times \mathbf{E}$ would be easy to detect. Presupposing suitable technology, this would enable a medical application: UWB beams resp. localized waves containing an LF component provide a method of non-invasive neural stimulation for diagnostic and therapeutic purposes, focused to a smaller volume than is possible with near fields.

References

[1] F. G. Mitri, "Quasi-Gaussian electromagnetic beams", Physical Review A 87, 035804, March 2013

[2] U. Hauser et al., "Time-dependent modulation of the probability amplitude of single photons", Physics Letters, Vol. 49A, No. 1, pp. 57-58, August 1974