What are “Scalar Waves”?

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Abstract

There is a wide confusion on what are “scalar waves” in serious and less serious literature on electrical engineering. In this paper we explain that this type of waves are longitudinal waves of potentials. It is shown that a longitudinal wave is a combination of a vector potential with a sacalar potential. There is a full analogue to acoustic waves. Transmitters and receivers for longitudinal electromagnetic waves are discussed.

Keywords: Electrodynamics, scalar waves, longitudinal waves, potentials

1 Introduction

With the appearance of experiments on non-classical effects of electrodynamics, authors often speak of electromagnetic waves not being based on oscillations of electric and magnetic fields. For example it is claimed that there is an effect of such waves on biological systems and the human body. Even medical devices are sold which are assumed to work on the principle of transmiting any kind of information via “waves” which have a positive effect on human health. In all cases, the explanation of these effects is speculative, and even the transmission mechanism remains unclear because there is no sound theory on such waves, often subsumed under the notion “scalar waves”. We try to give a clear definition of certain types of waves which can serve to explain the observed effects.

Before analysing the problem in more detail, we have to discern between “scalar waves” which contain fractions of ordinary electric and magnetic fields and such waves which do not and therefore appear even more obscure. Often “scalar waves” are assumed to consist of longitudinal fields. In ordinary Maxwellian electrodynamics such fields do not exist, electromagnetic radiation is said to be always transversal. In modern unified physics approaches like Eintein-Cartan-Evans theory [1]- [2], however, it was shown that polarization directions of electromagnetic fields do exist in all directions of four-dimensional space. So, in direction of transmission, an ordinary electromagnetic wave has

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a longitudinal magnetic component, the so-called B(3) field of Evans [3]. The B(3) field is detectable by the so-called inverse Faraday effect which is known experimentally since the sixties [4]. Some experimental setups, for example the "magnifying transmitter" of Tesla [6]- [7], make the claim to utilize these longitudinal components. They can be considered to consist of an extended resonance circuit where the capacitor plates have been displaced to the transmitter and receiver site each (see Fig. 1). In an ordinary capacitor (or cavity resonator), a very high-frequent wave (GHz or THz range) leads to significant runtime effects of the signal so that the quasi-static electric field can be considered to be cut into pulses. These represent the near-field of an electromagnetic wave and may be consiered to be longitudinal. For lower frequencies, the electric field between the capacitor plates remains quasi-static and therefore longitudinal too.

We do not want to go deeper into this subject here. Having given hints for the possible existence of longitudinal electric and magnetic fields, we leave this area and concentrate on mechanisms which allow transmission of signals even without any detectable electromangetic fields.

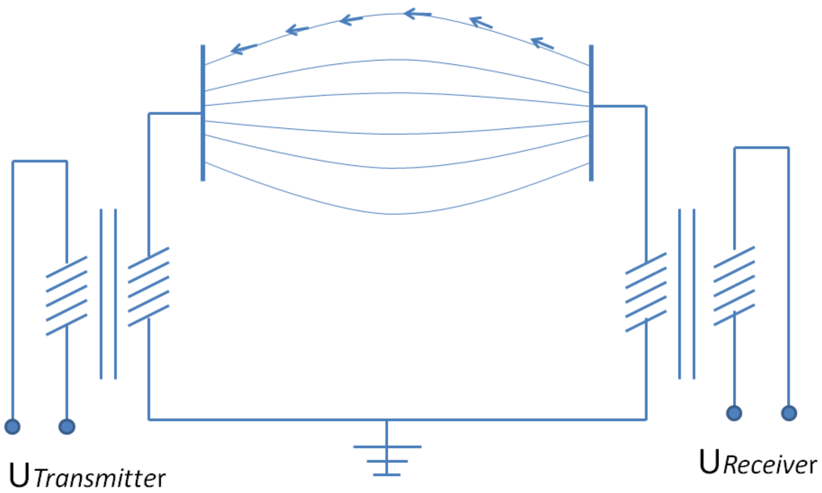

Figure 1: Propagation of longitudinal electric waves according to Tesla.

2 Longitudinal potential waves

In the following we develop the theory of electromagnetic waves with vanishing field vectors. Such a field state is normally referred to as a "vacuum state" and was described in full relativistic detail in [5]. Vacuum states also play a role in the microscopic interaction with matter. Here we restrict consideration to ordinary electrodynamics to give engineers a chance to fully understand the subject. With **E** and **B** designating the classical electric and magnetic field vectors, a vacuum state is definded by

$$\mathbf{E} = 0, \tag{1}$$

$$\mathbf{B} = 0. \tag{2}$$

The only possibility to find electromagnetic effects then is by the potentials. These are defined as vector and scalar potentials to constitute the "force" fields **E** and **B**:

$$\mathbf{E} = -\nabla U - \dot{\mathbf{A}}, \tag{3}$$

$$\mathbf{B} = \nabla \times \mathbf{A}, \tag{4}$$

with electric scalar potential U and magentic vector potential **A**. The dot above the **A** denotes the time derivative. For the vacuum, conditions (1, 2) lead to

$$\nabla U = -\dot{\mathbf{A}}, \tag{5}$$

$$\nabla \times \mathbf{A} = 0. \tag{6}$$

From (6) follows immediately that the vector potential is vortex free, representing a laminar flow. The gradient of the scalar potential is coupled to the time derivative of the vector potential so both are not independent of one another. A general solution of these equations was derived in [5]. This is a wave solution where **A** is in the direction of propagation, i.e. this is a longitudinal wave. Several wave forms are possible, which may even result in a propagation velocity different from the speed of light. As a simple example we assume a sine-like behaviour of **A**:

$$\mathbf{A} = \mathbf{A_0} \sin(\mathbf{k} \cdot \mathbf{x} - \omega t) \tag{7}$$

with direction of propagation **k** (wave vector), space coordinate vector **x** and time frequency ω. Then it follows from (5) that

$$\nabla U = \mathbf{A_0}\ \omega \cos(\mathbf{k} \cdot \mathbf{x} - \omega t). \tag{8}$$

This condition has to be met for any potential U. We make the approach

$$U = U_0 \sin(\mathbf{k} \cdot \mathbf{x} - \omega t) \tag{9}$$

to find that

$$\nabla U = \mathbf{k} U_0 \cos(\mathbf{k} \cdot \mathbf{x} - \omega t) \tag{10}$$

which, compared to Eq.(8), defines the constant $\mathbf{A_0}$ to be

$$\mathbf{A}_0 = \mathbf{k}\frac{U_0}{\omega}. \tag{11}$$

Obviously the waves of **A** and U have the same phase. Next we consider the energy density of such a combined wave. This is in general given by

$$w = \frac{1}{2}\epsilon_0 \mathbf{E}^2 + \frac{1}{2\mu_0}\mathbf{B}^2. \tag{12}$$

From Eqs.(5, 6) it is seen that the magnetic field disappears identically but the electric field is a vanishing sum of two terms which are different from zero.

These two terms evoke an energy density of space where the wave propagates. This cannot be obtained out of the force fields (these are zero) but must be computed from the constituting potentials. As discussed in [5] we have to write

$$w = \frac{1}{2}\epsilon_0 \left(\dot{\mathbf{A}}^2 + (\nabla U)^2 \right). \tag{13}$$

With Eqs. (7) and (9) follows

$$w = \epsilon_0 k^2 U_0^2 \cos^2(\mathbf{k} \cdot \mathbf{x} - \omega t). \tag{14}$$

This is an oscillating function, meaning that the energy density varies over space and time in phase with the propagation of the wave. All quantities are depicted in Fig. 2. Energy density is maximal where the potentials cross the zero axis. There is a phase shift of 90 degrees between both.

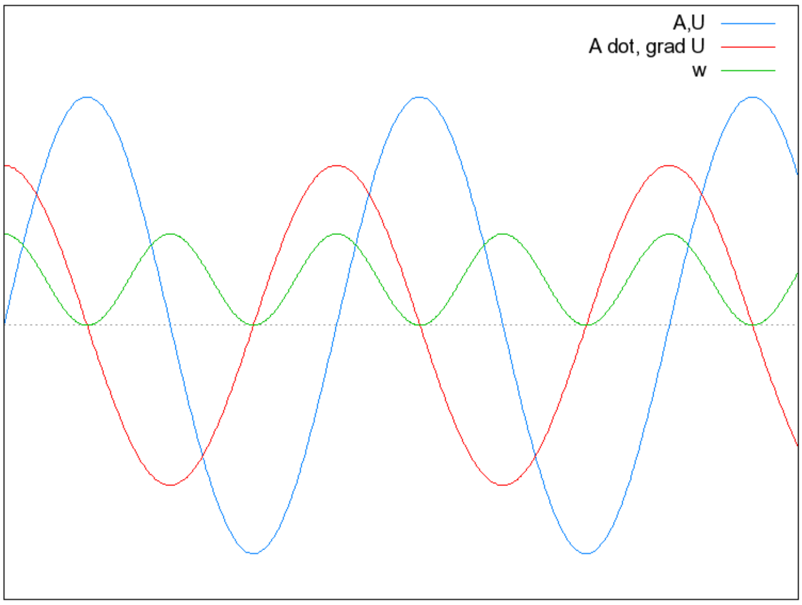

Figure 2: Phases of potentials **A** and U, and energy density w.

There is an analogy between longitudinal potential waves and acoustic waves. It is well known that acoustic waves in air or solids are mainly longitudinal too. The elongation of molecules is in direction of wave propagation as shown in Fig. 3. This is a variation in velocity. Therefore the magnetic vector potential can be compared with a velocity field. The differences of elongation evoke a local pressure difference. Where the molecules are pressed together, the pressure is enhanced, and vice versa. From conservation of momentum, the force **F** in a compressible fluid is

$$\mathbf{F} = \dot{\mathbf{u}} + \frac{\nabla p}{\rho} \tag{15}$$

where **u** is the velocity field, p the pressure and ρ the density of the medium. This is in full analalogy to Eq.(3). In particular we see that in the electromagnetic case spacetime must be “compressible”, otherwise there were no gradient of the scalar potential. As a consequence, space itself must be compressible, leading us to the principles of general relativity.

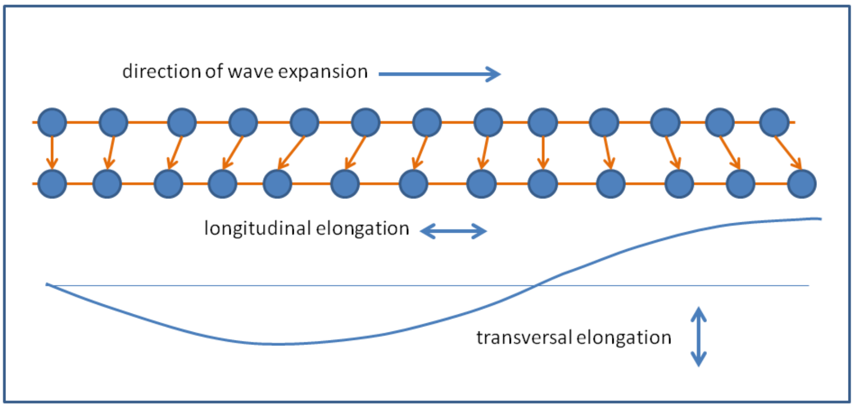

Figure 3: Schematic representation of longitudinal and transversal waves.

3 Transmitters and receivers for longitudinal waves

A sender for longitudinal potential waves has to be a device which avoids producing E and B fields but sends out oscillating potentials. We discuss two propositions how this can be achieved technically. In the first case, we use two ordinary transmmitter antennas (with directional characteristic) with distance of half a wavelength (or an odd numberof half waves). This means that ordinary electromagnetic waves cancel out, assumed that the near field is not disturbing significantly. Since the radiated energy cannot disappear, it must propagate in space and is transmitted in form of potential waves. This is depicted in Fig. 4. A more common example is a bifilar flat coil, for example from the patent of Tesla [7], see Fig.5, second drawing. The currents in opposite directions effect a nihilation of the magnetic field component, while an electric part may remain due to the static field of the wires.

Construction of a receiver is not so straightforward. In principle no magnetic field can be retrieved directly from $\mathbf{A}$ due to Eq. (6). The only way is to obtain an electrical signal by separating both contributing parts in Eq. (3) so that the equality (5) is outweighted and an effective electric field remains which can be detected by conventional devices. A very simple method would be to place two plates of a capacitor in distance of half a wavelength (or odd multiples of it). Then the voltage in space should have an effect on the charge carriers in the plates, leading to the same effect as if a voltage had been applied between the plates. The real voltage in the plates or the compensating current can be measured (Fig. 6). The "tension of space" operates directly on the charge carriers while no electric field is induced. The $\dot{\mathbf{A}}$ part is not contributing because the direction of the plates is perpendicular to it, i.e. no significant current can be induced.

Another possibility of a receiver is to use a screened box (Faraday cage). If the mechanism described for the capacitor plates is valid, the electrical voltage

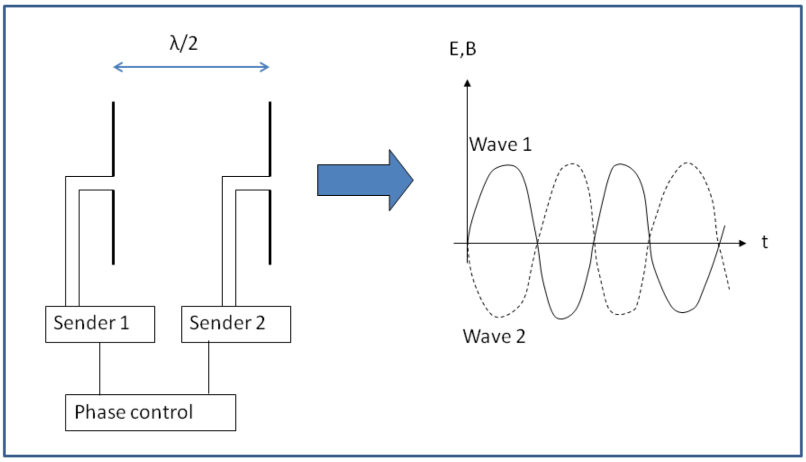

Figure 4: Suggestion for a transmitter of longitudinal potential waves.

part of the wave creates charge effects which are compensated immediately due to the high conductivity of the material. As is well known, the interior of a Faraday cage is free of electric fields. The potential is constant because it is constant on the box surface. Therefore only the magnetic part of the wave propagates in the interior where it can be detected by a conventional receiver, see Fig. 7.

Another method of detection is using vector potential effects in crystallline solids. As is well known from solid state physics, the vector potential produces excitations within the quantum mechanical electronic structure, provided the frequency is near to the optical range. Crystal batteries work in this way. They can be engineered through chemical vapour deposition of carbon. In the process you get strong light weight crystalline shapes that can handle lots of heat and stress (by high currents). For detecting longitudinal waves, the excitation of the electronic system has to be measured, for example by photoemission or other energetic processes in the crystal.

All these are suggestions for experiments with longitudinal waves. Additional experiments can be performed for testing the relation between wave vector k and frequency ω to check if this type of waves propagates with ordinary velocty of light c:

$$c = \frac{\omega}{k} \tag{16}$$

where k is defined from the wave length λ by

$$k = \frac{2\,\pi}{\lambda}. \tag{17}$$

As pointed out in [5], the speed of propagation depends on the form of the waves. This can even be a non-linear step fuction. The experimental setup of Fig. 6 can directly be used for finding the $\omega(\mathbf{k})$ relation because the wavelength and frequency are measuerd at the same time. There are rumors that Eric P. Dollard found a propagation speed of longitudinal waves of $\pi/2 \cdot c$ but there are no reliable experiments on this reported in the literature.

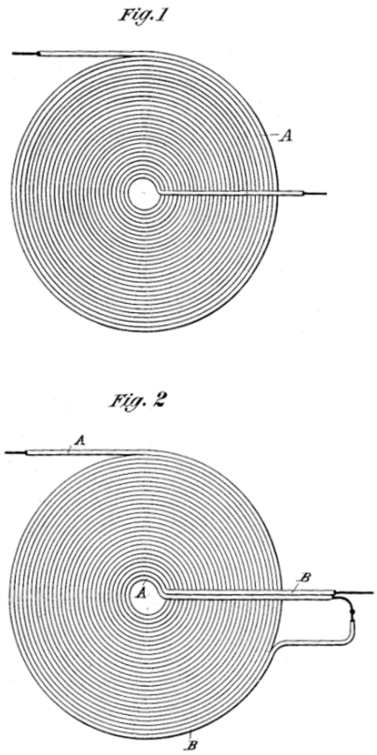

Figure 5: Tesla coils according to the patent [7].

The ideas worked out in this paper may not be the only way how longitudinal waves can be explained and technically handled. As mentioned in the introduction, electrodynamics derived from a unified field theory [1] predicts effects of polarization in all space and time dimensions and may lead to a discovery of even richer and more interesting effects.

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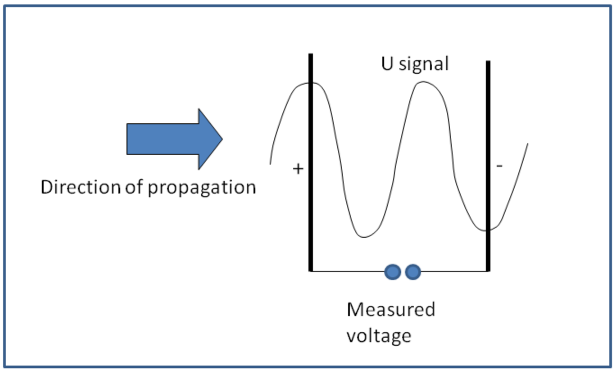

Figure 6: Suggestion for a receiver of longitudinal potential waves (Capacitor).

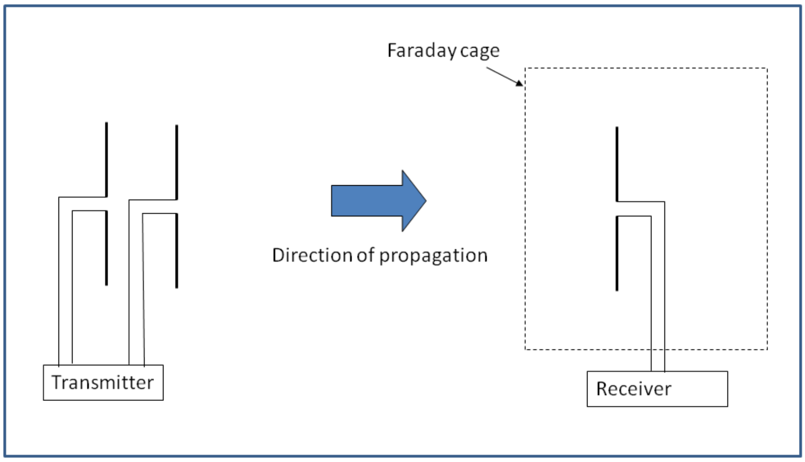

Figure 7: Suggestion for a receiver of longitudinal potential waves (Faraday cage).

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[7] U.S. Patent 512,340 "Coil for Electro-Magnets", Nikola Tesla (1894).