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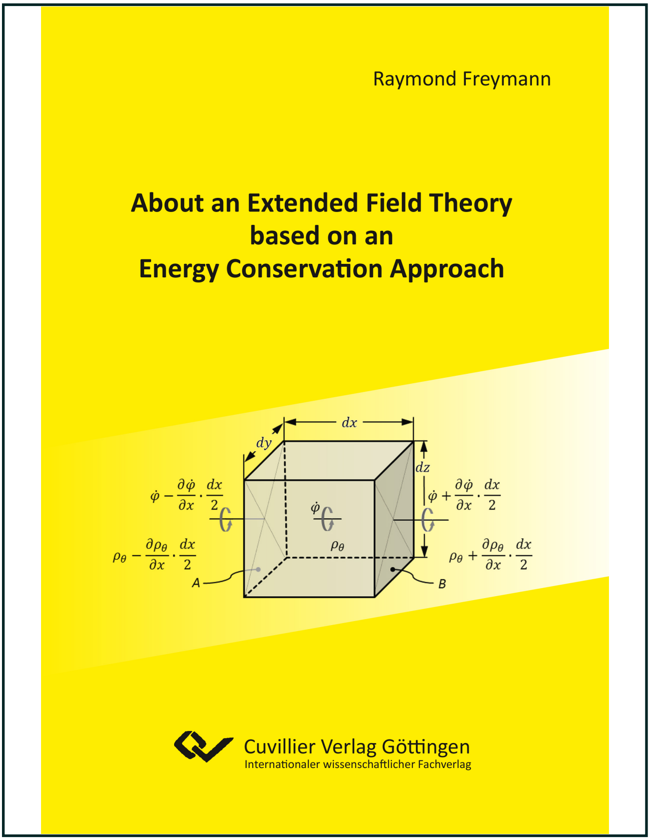
About an Extended Field Theory based on an Energy Conservation Approach



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1. Introduction

Yes, it´s all about curiosity! One day I was concentrating on the electromagnetic behavior of electrical ("50 Hz") transformers. This was just to understand how the energy transfer is realized in the "iron", the armature, to move the energy from the (externally excited) primary coil to the (energy receiving) secondary coil. I just wanted to know in detail what is going on in the "iron".

I studied a lot of literature on the Internet and by doing so, just by pure incident and real unexpectedly, I was confronted with the wave propagation topic in an electromagnetic free-field. I really dived in into this topic with the expectation to get a deeper understanding about the energy content being related to an electromagnetic field. And, I need to admit, by digging deeper and deeper more and more questions were brought up. All of this first appeared as to finish in a so-called endless story.

When concentrating on the electromagnetic free-field, I was in some way surprised by the simplicity of the corresponding physical background when compared to the overall electromagnetic situation related to solid materials /1/. What struck me most was that in a propagating free-field there are just two fields existing, an electric $\mathcal{E}$ - field and a magnetic $\mathcal{B}$ - field, located in a vertical plane relative to the wave propagation direction. Both *fields, being in-phase* and vertically oriented to one another, may indeed create – in accordance with Lorentz´s law or Ampère´s force law - an environment allowing an electrically charged particle to be moved in the direction of the so-called pointing vector, which is the direction of the wave propagation. Yes, all in all it looks quite plausible, but the longer I was concentrating on the possible physical mechanisms involved, the more I got the impression that there must be "something" missing.

Just having an engineering background (in aeronautical sciences), I had to notice soon that it might not be easy to come up with a decent explanation/solution in context with the topic addressed. There were so many (additional) constraints existing which needed to be considered: the particle/wave properties of the electromagnetic field as well as the quantum theory. Accordingly, at a very first glance, all of this appeared to be of a "highly complicated matter" and – as is noted in so many publications – there is no way existing to explain this highly complex topic by an approach based on "classical physics".

With this a priori information, I had to recognize that my starting position to tackle the topic was rather bad. I really have no deep insight into the physics on the particle level. On the other hand, I dare to say that I have a lot of experience as to deal with energy considerations on a more global level, say on the field level. Accordingly, I decided to analyze the electromagnetic field physics on an energy conservation approach.

Since the electromagnetic field does in many respects still lack transparency, I first went on looking at “possibly related analogies” in other technological fields. And … I did identify similar effects in acoustics, the acoustic wave propagation! The similarity is due to the fact, that in an acoustic free-field environment, the pressure and the acoustic celerity *fields are in-phase*, which is (at least superficially) similar to the $\mathscr{E}$ - and $\mathscr{B}$ - fields in an electromagnetic wave propagation field. Moreover, the acoustic free-field does feature both particle and wave characteristics, just in the same way as the electromagnetic field does.

To cope with this fact, a deeper focus will be pointed in Chapter 2 on the wave propagation in an acoustic free-field environment. Since both, the acoustic and electromagnetic fields – at least at a first glance – seem to have some commonalities, it appears to make sense to first concentrate on the more transparent acoustic free-field before addressing the more complex electromagnetic topic in Chapter 3. In the scope of related detailed analysis, the “missing part”, being inherent both to the acoustic and electromagnetic fields, could be identified. The missing part is a “rotational field degree of freedom”!

Having set up the physical model of the electromagnetic field and having derived the related energy equations, the next task consisted in the verification/calibration of the derived extended model. It was considered that the black body radiation (Planck´s radiation spectra) was best suited to validate the elaborated theoretical model. In Chapter 3 we will focus on the validation process which finally proved to be successful. Thereby also an explanation about the so-called “ultraviolet catastrophe” will be given. A simple physical reasoning will indicate that this catastrophe cannot exist!

Moreover, in Chapter 3, characteristic values, being related to the medium on the particle and volume level, will be derived by introducing an extended formulation of the thermodynamic equations related to the perfect gas theory.

Having demonstrated that there is a significant evidence existing that the acoustic and electromagnetic fields are physically similar, some further considerations can be derived therefrom. These will be addressed in Chapter 4 with focus pointed on the topics of “superlight speed”, the photoelectric effect and an (assumed!) gravity mechanism.

Finally, it should be mentioned that the work outlined in *the publication is primarily focusing on the identification and explanation of physical phenomena* related to the dynamics in a sustained free-field environment. Thereby use will be made of an approach being completely based on classical physics/mechanics. In the scope of the investigations just a first order approximation is considered to mathematically describe the field dynamics. This is of no major significance as to the results/information obtained from the related physical considerations which appear as logical and convincing. This is among others due to the fact, that the (many) field energies involved are forming an overall completely balanced dynamic system, being at resonance at any location, at any time and at any frequency. The overall dynamic behavior and performance of the system is so remarkable, just absolutely (!) perfect.

2. Acoustic wave field

For the sake of simplification let´s concentrate first on the one-dimensional acoustic free-field, as depicted in **Fig. 1**. Thereby it is assumed that the field is propagating from a source to a sink. Let´s just focus on a *sustained harmonic* free-field existing between the source and the sink. The free-field is characterized by the fact that both the pressure and acoustic celerity fields are in-phase all along the propagation x-axis /2/. Accordingly, the pressure and celerity fields, p and $\dot{\xi}_x$ respectively, can be expressed in the form

(1) $p = p_0 \cos(\omega t - kx)$,

(2) $\dot{\xi}_x = \dot{\xi}_{x0} \cos(\omega t - kx)$.

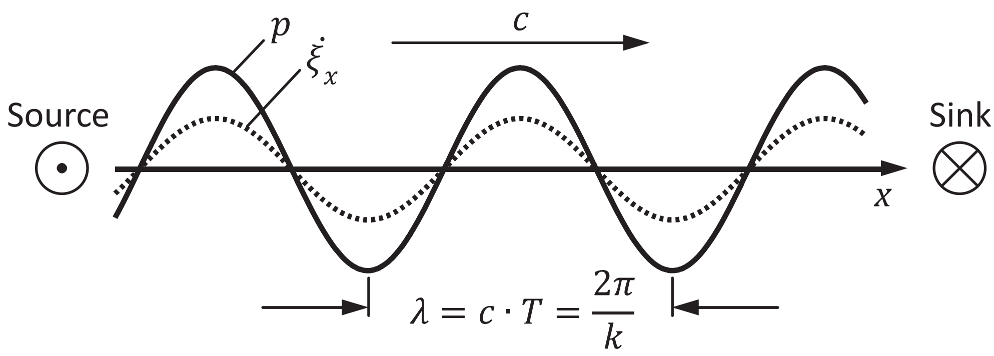

Figure 1: *One-dimensional acoustic free-field*

In Eqs. (1) and (2) p_0 and $\dot{\xi}_{x0}$ are denoting the amplitudes of both variables, ω defines the circular frequency of the time dependent harmonic signals and k the phase constant describing the harmonic wave pattern as a function of the x-location. With λ defining the wave length of the harmonic field, T its time period and c denoting the speed of sound in the medium, leads moreover to the following interrelation

(3) $\omega T = k \cdot \lambda = k \cdot c \cdot T = 2\pi$.

There is no need to say that Eqs. (1) and (2) are related to waves propagating in the positive x-direction. Accordingly, these waves are constantly transporting energy in the positive x-direction of the wave field.

But how about the energy content related to a defined *fixed size* volume element positioned at a *fixed* x-location (**Fig. 2**) within the field? Based on an energy conservation approach, we can write

$$(4) \qquad \frac{d}{dt}(E_A - E_B) = \frac{d}{dt}(E_{kin,V} + E_{pot,V}),$$

E_A, E_B denoting the acoustic input and output energies to the volume element, respectively, and $E_{kin,V}$, $E_{pot,V}$ defining the kinetic and potential energies inherent to the volume element itself.

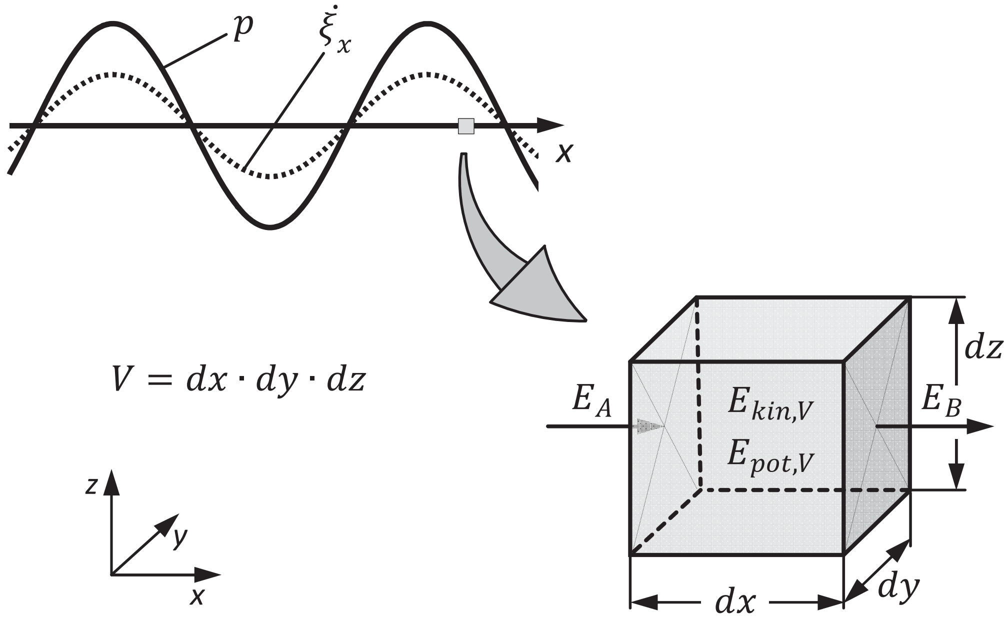

Figure 2: *Energies related to a volume element*

Eq. (4) leads to a significant finding. If the length (in the x-direction) of the fixed size volume element is identical to the wavelength λ or to an integral multiple of this wavelength, then – in case of a sustained harmonic acoustic field – its kinetic and potential energy content will not vary over time. It follows therefrom that $E_A = E_B$ in any time interval, say "what´s coming in is going out". The interesting story behind this is as follows: *neighboring elements can transfer energy to/among each other without changing their own energy content* (**Fig. 3**). Of course, this finding is resulting from a rather macroscopic approach, microscopic considerations would indicate that there is a lot "going on" in the volume element itself. Nevertheless, this is a highly interesting finding!

If we now focus on a fixed size volume element of length $dx << \lambda$, we need to consider the microscopic dynamics in the medium. In this context let´s just address the potential energy changes inherent to this real small volume

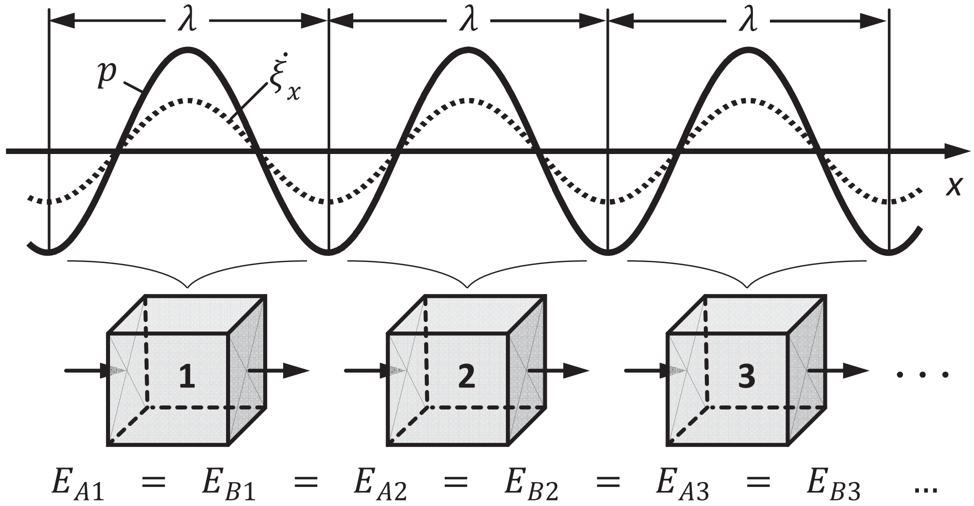

Figure 3: *Energy transfer between volume elements*

element resulting from the dynamic pressure fluctuations. Let´s focus on the narrow dx-slot being indicated in **Fig. 4.**

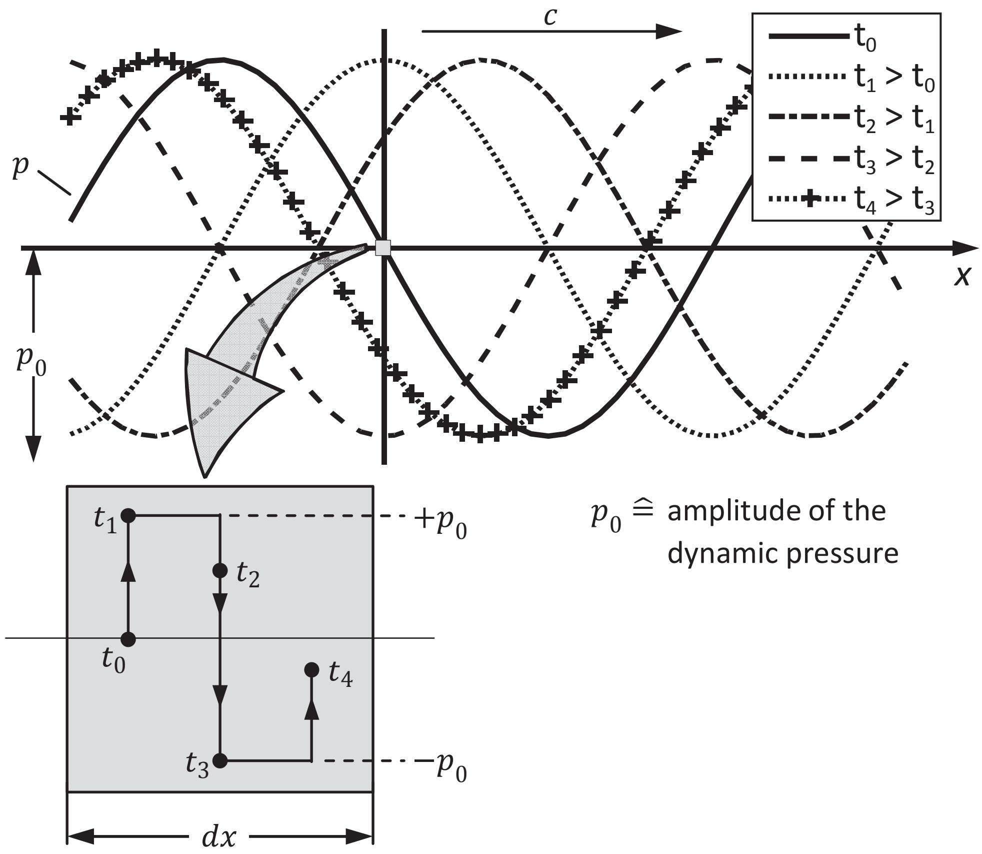

Figure 4: *Timely dependent pressure fluctuations in a volume element*

The dynamic pressure will increase in a first time interval (compression), will be reduced in a second time interval (expansion), will feature negative values in a third time interval (dilution), will increase again in a fourth time interval (compression) and this will be repeated all over time. At a first glance, all of this looks quite logical. Potential energy is built up in a first step, then recovered in a second step and so on and so on. And finally, the related energy variations will be longitudinally transferred to a next neighboring volume element in accordance with Eq. (4).

A second glance at the situation reveals that this compression and dilution work cannot really be performed in the scope of an efficient process. It all looks so "unbalanced". It appears like moving up and down an elevator having no counterweights. There must be "something" missing.

To clear up the situation, let´s focus on the following *virtual* experiment. Let´s assume that, as is indicated in **Fig. 5**, a noise source (loudspeaker) is placed on a flat surface and is homogeneously radiating "noise" into a spherical half-room. This entails that sound pressure levels are equal on (half-) shell surfaces being equidistant from the noise source. Let´s further assume that the noise emitted by the source is harmonic with time and at a frequency of 1000 Hz. The excitation level of the noise generator is adjusted to produce - at a 1 m distance – a sound pressure level of 74 dB, which corresponds to an *effective*

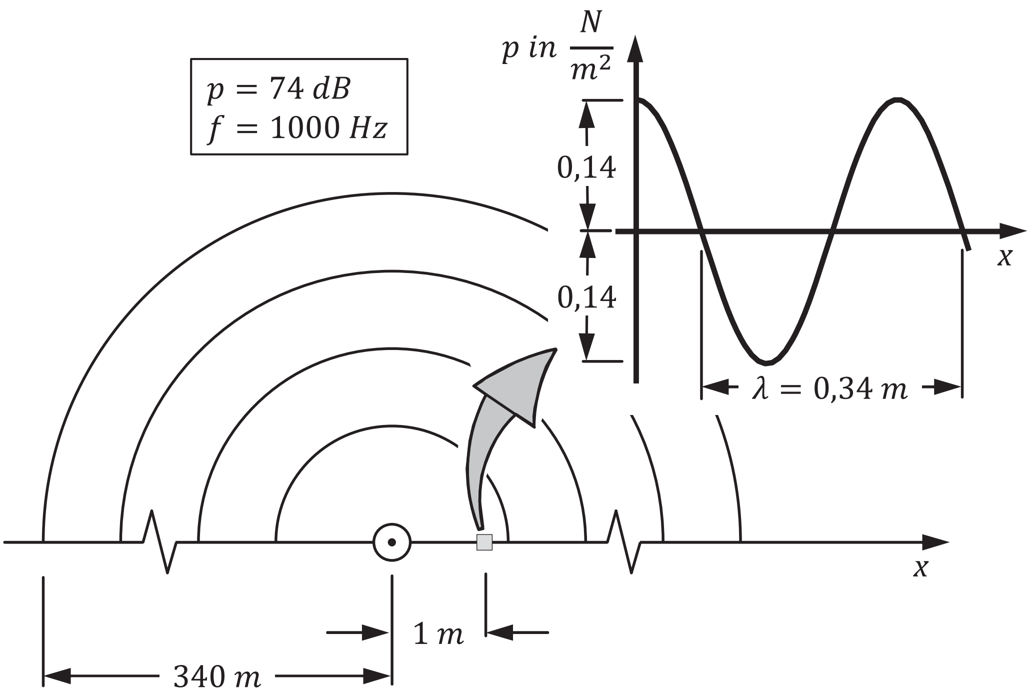

Figure 5: *Virtual experiment*

sound pressure of 0,1 N/m². This may be considered as a medium noise level as to the audible perception of human beings. This is for sure not “loud noise”.

Based on the test setup described, we now perform a *virtual* test run being defined by the following 3 states:

State 1: The noise source is not activated ... no ambient noise, just dead silence.

State 2: The noise source is switched on and noise is radiated into the spherical half-room. The noise propagation will occur at the speed of sound, say 340 m/s.

State 3: Just one second after having activated the noise source let´s (virtually) freeze the radiated noise field and switch off the noise source. At this statically frozen 1 sec. time point the noise has spread around the noise source, creating a half-spherical sound field ranging from 0 m to 340 m relative to the noise source location. Evaluating the acoustic energy inherent to this frozen acoustic field will allow to determine the required energy/power of the noise source to produce the noise field.

Evaluating the energy content of the (frozen) field we will just focus on its potential energy. The kinetic energy is negligible. Moreover, it is well-known that the acoustic energy in half-shell volume segments of equal thickness is of a constant value and thus independent of their corresponding distance relative to the noise source. This allows to just determine the acoustic energy content in one shell volume – e.g. being of 1 m thickness - and multiply this value by a factor of 340, 340 m being the extension of the frozen noise field.

Let´s now evaluate the potential energy being inherent to the shell volume segment ranging from 0,5 m to 1,5 m from the noise source. We defined the noise pressure level existing at a 1 m distance from the noise source: $p_{eff} = 0{,}1\, N/m^2$. In the volume considered there are areas of compression and dilution of the medium existing. Now it needs to be understood that both the compression and the dilution of the medium require the input of energy to the field. In this context, just let me note that it is not allowed to consider compression areas as “positive energy areas” and dilution areas as “negative energy areas”. This is not true. Positive and “negative” energy areas do not compensate! Both compression and dilution need *positive* (!) work to be performed.

In the scope of an energy approach this finally allows to take into account the (positive and "negative") dynamic pressure fluctuations over a wavelength by a static *averaged* positive pressure value p_{avg}, defined by the following equation:

(5) $$p_{avg} = \frac{1}{\lambda/2} \cdot p_0 \int_0^{\lambda/2} \sin(kx) \cdot dx = \frac{2}{\pi} \cdot p_0 = \frac{2}{\pi} \cdot \sqrt{2} \cdot p_{eff} ,$$

p_0 characterizing the (dynamic) peak pressure amplitude and p_{eff} the related effective pressure amplitude. The interrelation existing between both of these values is $p_0 = \sqrt{2} p_{eff}$.

Based on the considerations made above, the dynamic potential energy of a field volume can now be written as follows:

(6) $$E_{pot} = [V] \cdot [p_{avg}] .$$

Concentrating on the half-shell volume between the radii $R_{inner} = 0{,}5\ m$ and $R_{outer} = 1{,}5\ m$ leads to

(7) $$E_{pot,1m} = \left[\frac{1}{2} \cdot \frac{4}{3} \pi \cdot \left(R_{outer}^3 - R_{inner}^3 \right) \right] \cdot \left[\frac{2}{\pi} \cdot \sqrt{2} \cdot p_{eff} \right]$$

$$\hat{=} \left[\frac{1}{2} \cdot \frac{4}{3} \pi \cdot \left(1{,}5^3 - 0{,}5^3 \right) \right] \cdot \left[\frac{2}{\pi} \cdot \sqrt{2} \cdot 0{,}1 \frac{N}{m^2} \right] = 0{,}62\ Nm .$$

Multiplying this value by a factor of 340 finally yields the total dynamic potential energy inherent to the acoustic field according to

(8) $$E_{pot,340m} = 0{,}62\ Nm \cdot 340 = 210\ Nm = 210\ Ws .$$

This *acoustic* energy has been provided by the noise source in a one-second time interval. Knowing that the electro-acoustical efficiency of a sound generator is rather poor, let´s assume an efficiency factor of 1% in case of a simple loudspeaker system, which can (easily) generate the 74 dB dynamic pressure level at a distance of 1 m from its location. This entails that the *electric* energy which needed to be provided to the loudspeaker system – in this 1 second time interval – is in the range of 20.000 Ws. The thus related *electric* power request amounts to 20 kW! Reality now shows that a battery powered "small device" can produce the sound levels considered with an