Electric/magnetic bifurcation

Existence of a phenomenological transition

Before pursuing further discussions on conceptual issues related to this amazing near-field, it could be wise to demonstrate, in a more quantitative manner, the existence of a clear transition between far-field and near-field situations.

To do so we will take into consideration elementary sources made off perfect electric or magnetic dipoles. We will use the frame of the dipolar approximation, so we will assume that we are posted relatively far away from the dipoles.
It could appear strange to consider the dipolar approximation of a perfect dipole constituted of two punctual charges. It only states, as introduced in the first article concerning the near-field concept, that we use a mathematic simplification that arise when the observation distance is large compare to the dipole size (the distance between the two charges).
It is important to note that this is only a geometric approximation and that nothing is assumed concerning the wavelength and as a consequence the EM relative proximity of the observation point and on the ability of the device to radiate efficiently its energy away. Then, it will be possible, in situations where the dipole size will be much smaller than the wavelength to consider both near-field and far-field regions.

To a large extend Maxwell's equations are based on original empirical considerations. It is worth noting that the displacement current term was introduced ex-nihilo by Maxwell himself for homogeneity reasons[1]. Nowadays these equations reflect everything that could be observed in the classical frame of electromagnetism. We will use them as a starting point for our quantitative analysis. For the concerned elementary dipoles, it is possible by making use of retarded potentials[2](1) to find expressions for electric and magnetic fields that are exact solutions of the whole set of Maxwell's equations. The interested reader could find a demonstration for instance in (2).

In order to bring the results in a more elegant and demonstrative manner, we will consider the fields **E** and **H** only along a direction transverse to the dipole axis. This fields exhibit the property to be at right angles. We will moreover restrain ourselves to consider only the ratio of the modulus of these two fields[3]. This quantity can be computed all along the axis in the dielectric medium or the vacuum, it is homogenous to impedance[4].

[1] Without this term the obtained equations would have violated the electric charge conservation principle.
[2] It concerns a generalization of static potentials to take into account the finite propagation time of interactions.
[3] Because the two fields **E** and **H** are vectors with complex coordinates, it is difficult in the general case to find a meaningful ratio between two quantities that have varying amplitudes and simultaneously varying angles between them.
[4] In the classical frame the vacuum appears as a continuous medium with specific electromagnetic properties.

If we represent both situations in the same graphic we obtain the following curves; the magnetic case is figured in red whereas the electric one is in blue.

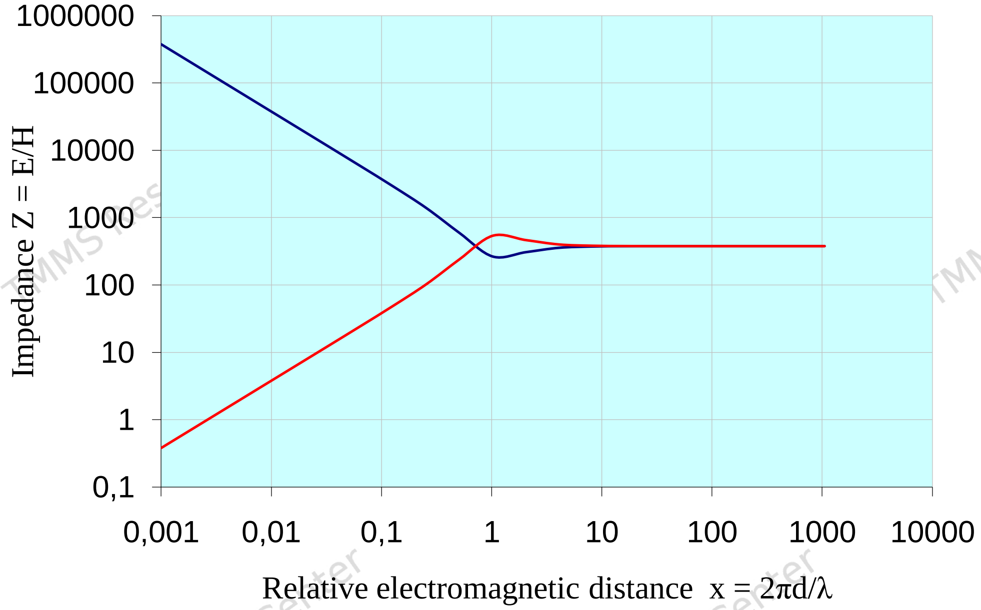

Fig.1: EM field impedance along the transverse axis as a function of relative EM distance

In the far-field case, we see that we obtain the same constant impedance. In this area the ratio between the electric field and the magnetic field is not dependent on position and of the nature of the device generating the field. This impedance is called the characteristic impedance of the vacuum, its value is: $Z = \sqrt{\frac{\mu}{\varepsilon}} \approx 377\ \Omega$

In the vicinity of sources the behavior is completely different. One field become predominant according to the device involved. In contrary to far-field situation we see that the vacuum impedance get farther and farther from its characteristic value as we get closer to the source. Moreover this impedance depends now on the nature of the device.

We will see that it is possible to find appropriate approximations to the Maxwell's equations system in every case:

- In the far-field case we will obtain coupled propagation equations for both fields.
- In the non-radiating near-field case we will distinguish two cases according to the dominant electric or magnetic field.

The non-radiating near-field cases correspond to situations where we may consider that the fields propagate instantaneously in the volume under consideration. It concerns cases where the phase difference due to propagation between two different positions is everywhere negligible in the domain. In an equivalent manner, it is possible to retrieve the specific laws

for these two regimes by increasing the light velocity toward infinity in the Maxwell's equations[1]. Equations obtained this way do not depend any more on the speed of light.
It results from the preceding that **the nature of the mathematical problem changes when one shift from far-field to near-field situations**[2]. In the far-field case, the fields are self consistent, it means that they generate each other mutually all along propagation whereas in the near-field case the fields are linked to matter presence. As a result, a near-field problem can only be closed by the adjunction of "mechanical" considerations. In practice it leads to the inclusion of new equations and constraints such as the Lorentz force formula for individual free particles. **The problem that is so obtained forms a non-dissociable whole, charges and fields being intimately linked in all the points of the domain. Reversely in the far-field case, the self consistent character of the fields enables to study their propagation locally in a manner fully independent on the source that produced them.**
It is this useful local character opposed to the global aspect of the near-field that dominates the standard model for particles.

How to conceptualize such a situation?

It seems natural to considerate the near-field as intimately associated to charges then to matter and the far-field as composed of waves seen as autonomous objects propagating freely at some distance.

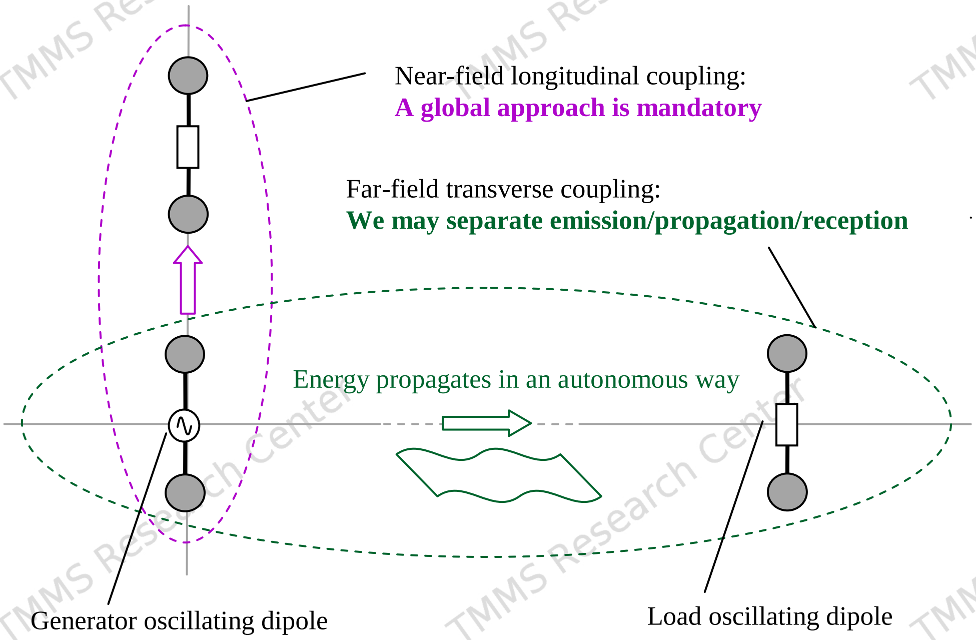

Fig. 2: Longitudinal mode (quasi-contact) and transverse radiative mode.

[1] To avoid inconsistencies it is necessary to treat separately the case where the electric field is dominant from the one where the magnetic field is dominant.
[2] More precisely the far field is described by an equation that implies second order derivatives whereas the near-field obeys to a first order system of equations.

It is possible to further develop this idea at the elementary level by considering in a first step a single electron.
The electron having no identified internal structure, it is not possible to attribute directly a size to it[1], as a result the idea of geometrical relative distance as no meaning. For a static electron there is no way to know if you are far or near it if you only use the field profile with distance.
On another hand it is possible to define a relative EM proximity according to its movements and more precisely according to its acceleration that enable it to radiate some energy away. It is then possible as we did in the past to use the wavelength of the radiation to measure the relative distance.
When two quasi-static electrons are placed in their respective near-field, everything looks like there is no propagation and like if the two electrons are in instantaneous contact. It is this property that enables the use of the classical idea of force.

The frequency that one considers for a macroscopic charge made of a great number of electrons is the same that the one that applies to every electron. The size of the macroscopic structure is then identical to the one of any electron composing the charge. It results that it is equivalent, for devices with sizes much smaller than the wavelength, to consider electrons in quasi-contact or macroscopic objects in quasi-contact.
According to the phenomenological non-separable character of the near-field relative to the material charge, it is possible to attribute to the electron a relative size, the one of its near-field domain. This size is infinite for an electron at rest or in a uniform translation and becomes very small if one tries to probe this electron with another one of a high relative velocity (in such a case the electron originally at rest is strongly accelerated and the size of its near-fields is strongly reduced).
However one has to be careful not to attribute to the electron a picture of a solid spherical extensible envelop[2], but more appropriately an evanescent structure following the $1/r^2$ rule (according to Coulomb's law). The physical nature of the underlying structure is a delicate subject allowing only metaphysical conjectures according to our present knowledge. For instance one may consider the vacuum as a kind of elastic medium under stress, the electric field being a measure of the local intensity of the stress and the magnetic field the kinetic aspect of the situation when the charge is moving. This virtual medium, immaterial by essence, is not accessible to direct measurement (3).

A new difficulty is linked to the blurred aspect of this extension. A picture coming from fluid mechanics may help to understand a little more this idea. Let's assume that our electron is a kind of cyclone and that its energy spreads on large distances but with a decreasing force as distance is increased[3].

Let's now wonder on the question of the real extension of the cyclone. The natural answer is: theoretically infinite[4]. However in practise, at large distance from its eye the winds became so weak that the smallest local breeze will make anyone forget the very existence of the far object. A clear conceptual dichotomy arise here: do we have to conceive the cyclone as a

[1] Apart by considering electromagnetic energy and the measured mass of the latter
[2] For instance a inflatable elastic balloon.
[3] Be careful such a picture is naïve; there is now way in a 3D fluid to take into account the isotropic energy distribution as observed in the electron case.
[4] For a stationary situation, then for a vortex fully established (which takes a time theoretically infinite)

punctual object moving in a perturbed fluid or do we have to conceive that the object occupies the whole space?

The answer that we propose here is to conceive an extended object but to limit its practical extension to the process involved. In this acceptation it is possible to conceive that a cyclone can have an infinite extension if it is alone in space and established for a time itself infinite and that at the same time one could neglect its presence at a certain distance if other phenomena leading to strongest effects should be taken into account.

Fig. 3: Is a cyclone punctual or infinitely spread?

This concept of particles with an infinite extension in an evanescent manner enlightens, in the gravitation frame, the Mach's principle and Einstein's general relativity theory. According to both, it is the far masses that give a structure to our local space.
If we pursue this idea to the limit, in a classic picture the vacuum could not exist alone; it could be described as the global manifestation of the cumulated evanescent extension of all the particles of the universe[1]. Reversely in the quantum picture; particles could be seen as a local quantified state of the vacuum. In both cases, it could only be possible at the fundamental level to dissociate the two objects by global purely geometric attributes in the classic frame or by numbers to characterize the local state of the vacuum in the quantum frame. Everything could be reduced "in fine" to the characterization of a single universal perturbed medium.

[1] It obvious that the term "vacuum" is a pretty bad choice in such a case, it will be better to use for this underlying substrate the term "space-time" or even more explicitly by using Einstein proposal: "substratum".

The non-radiating near-field practical applications

The force applying between two electrons separated by a 1m distance is extremely small: $2{,}3.10^{-28}$N. However if we compute the force applying between two macroscopic charge quantities, this force may become huge: $8{,}35.10^{19}$N for two moles of electrons at the same distance. For reasons already explained, such a macroscopic charge is not allowed by surrounding matter. Values we may reach for the charges in practical applications will be limited to much smaller amounts.

These quasi-contact forces at a distance can be used in different manners:

- In purely mechanic forms, that is to say on situations where solid parts are moving relatively to each other as in motors or usual generators.
- In the form of actions between mobile charged particles moving inside material devices staying themselves at rest as in coupled electric circuits at a distance.
- Or finally in the intermediate form, where the distant forces generated by a device is applied to a charged fluid and where the moving charges drag or act on the neutral fluid at a larger scale in a coherent manner (or reversely). This action is made without the use of any mobile solid parts as in MHD or EHD devices.

The following will concern only the two last types of devices. The development of high-frequency high-power performing components may involve for such emergent technologies large improvements in terms of range, efficiency, miniaturization…

For the readers convinced that electric or magnetic forces cannot be used in order to transfer an appreciable amount of power for distances higher than a few centimeters, let's remind that the power is the product of force by velocity and that even a small force can lead to an arbitrary high power provide the velocity of the object the force is applied to is high enough. In the case of MHD and EHD devices, the velocities of the charges and of the fluid they set into movement are the key parameters in order to reach high efficiency and power. In the case of coupled circuits velocity is linked to frequency and as a result it is the increase in frequency that leads to a rise of transferred power. However at large frequencies a compromise should be made between locally transferred power and power radiated far away.

In parallel with modern technologies able to produce high fields at relatively large frequencies, a better understanding of physical processes such as double resonance, impedance tuning and their practical limits, is absolutely necessary to carry on the optimization of induction and influence devices.
All these subjects will be developed in details in this website pages.

Note that some microscopic phenomena not described here, such as induced fluorescence (FRET) or induced transparency, could be described by semi-classic models that are to a large extend inspired from results explained in this work.

Conclusion

Applied to the fields produced by elementary dipoles, the phenomenological approach reveals two clearly defined areas; the near-field and the far-field regions. Mathematical and conceptual tools used to treat both situations are very different. This leads to consider that a truly fundamental bifurcation exists between these two domains; the near-field being intrinsically linked to the material charge whereas the far-field is autonomous. It is then possible to wonder if the "standard" position that consists in assuming the electron as perfectly punctual is the best choice or if it would not be more suitable to consider an extended electron even if this extension should be made variable according to situations. This conceptual choice is beside conform to the Mach's principle. On what concern the very nature of this extension, it differs according to the frame: in the classical domain it could take the form of a space-time curvature/strain that will be measured locally by the fields. In the quantum picture it could appear as a diffuse halo of virtual particles. A convergence between these two perceptions is possible if one assume that the particle doesn't differ fundamentally from the vacuum surrounding it. In this approach only one medium would exist and not two entities of different natures.

The idea is not the reintroduction of the Maxwell/Lorentz "ether" because the latter was conceived as a material medium of a different nature than the particles crossing it. It is not a variant of string theory because strings are also conceived as autonomous objects with a nature different from the surrounding medium. It is really a new heuristic approach based on a single object where particles and vacuum will only be implementations that could be explained by geometrical characteristics associated to "state" numbers in the quantum picture.

In this website we will not dwell further into metaphysics, our only ambition is to put some light on the existing formalism by using the conceptual frame explained above. It is, according to us by keeping in mind this conceptual issue that the reader should grasp the specific character of non-radiating near-field applications. The best pragmatic way to picture such situations is the use of the distant force concept that could be also seen as an evanescent instantaneous contact between objects.

This website treats of the use of such forces in the frame of solid state devices. Such devices enable to transfer energy at a distance in two main forms. Actions in the bulk of a fluid lead to unchallenged possibilities for instance the removal of turbulences or shock waves for supersonic velocities. Energy can be transferred between two distant coupled resonant circuits in order to complete in a convenient way the Nicola Tesla wireless world dream.

Appendix

On the relative uselessness of quantum electrodynamics at the conceptual level

In the standard model of modern physics all forces are seen as local interactions between punctual particles. Interaction vectors themselves are represented by particles[1]. In that model, electromagnetic interactions, that explain all we see and manipulate around if we excluded nuclear and gravitation phenomena, are all brought through quantum electrodynamics (QED) to discrete local electron/photon interactions (4). Let's say simply that from QED as vulgarized by Feynman, we only keep in mind an extremely naïve picture: only two interacting objects exist; the punctual electrons and the photons standing for the electromagnetic field.
This conceptual approach is hardly compatible with our everyday experience of reality. For instance, if it is possible to figure that the light can take a wavelike behavior similar to sound waves in gases or waves on the ocean surface and also could take in the optical geometry frame to an idea of trajectory for light particles; it is much more difficult to get a representation of the repulsive/attracting forces of two magnets or to electrical charges in the same frame.
We could naively try to imagine that the electrostatic energy stored in a capacitor correspond to a photon gas applying a resulting statistic force on electrodes, however this position is hardly defensible for several reasons.
Firstly it would require an astronomic number of photons because at low energy each photon carries a very small amount of energy and its corresponding amount of momentum is even smaller ($p=E/c$). But above all this photon gas has to be mainly outside the capacitor, if not how to explain that the resulting force is attractive. Then how to explain that these photons do not escape away leading to the immediate discharge of the capacitor?
The same problem for the sign persists at the microscopic scale. If one considers for instance the interaction between an electron and a proton, the classical picture of an interaction through an exchange of particles does not stand because the emission/absorption always leads to a backwards force. Besides how to treat the static case, what kind of process triggers the emission of photons when the two particles are initially at rest?
So how QED tackles the non-radiating near-field case?
To start with the photon is not seen as a classical particle, if it carries energy and momentum, it has no defined position in time and as a result the idea of trajectory do not apply to it[2] (5). More precisely, in a very upsetting way, it is nowhere except at the moment and place it is detected. The idea of a photon gas that will justify the classical local energy density is then meaningless[3].
The free escape in space issue is solved by considering these photons as virtual ones, that is to say that they have a lifetime (and then a range) so short that they could not be observed; only their global behavior has a physical meaning. This is very important; it means that these photons are only a way to keep the mathematical scheme in the same paradigm and that an alternative interpretation is allowed. Let's finish this rapid survey of QED frame by adding that the idea of virtual photon is not sufficient to describe the near-field behavior. According to authors, one can find scalar or longitudinal photons and associated to the dominating electric or magnetic aspect of the near field; multipolar electric or magnetic photons (6).

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[1] This particles however differ from material particles by some physical and statistical properties
[2] At least at the individual level
[3] Another way to state the problem is to say that the photon has no mass even if it transports some energy. One should also note that in the classical frame the local density of energy has no physical meaning, only energy balance is meaningful, so there is no incoherence up to here.

To summarize QED applies the quantification process to the electromagnetic relativistic frame. This formalism treats the near-field in a much more complex and indirect manner than the far-field. It is possible to some extent to keep the formalism in the standard model frame. This is done through the introduction “ad nihilo” of new virtual particles that have, taken individually, no physical meaning[1]. This attempt to stay in the same paradigm leads to surround the central singularity with a cloud of virtual particles. The number of involved particles growing to infinite if the development technique is spread infinitely[2]. This position is justified only by the belief that a local description through punctual particles is the only possible way. This is a dogmatic attitude; a more natural position, following the Occam razor principle, is obtained in the practical case of the electromagnetic near-field by considering simple phenomenological arguments. It leads to consider a fundamental breaking not between the pin-pointed electron and the vacuum surrounding it but at a certain distance from the electron center. Further analysis leads to consider an extended elemental charge of the same fundamental nature than the vacuum surrounding it. If this idea could be extended to other forces and particles it will change drastically our picture of the world, rising non-locality and geometry as central features of a new paradigm.

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[1] Feynman’s diagrams correspond to a world that is not accessible to measurements
[2] This has also no meaning because the computations start to diverge after a certain time.