Quasi-contact at a distance

The concept of force at a distance

Let's see now how we can formalize and conceive clearly energy transfer at a distance for systems of both types (non-radiating near-field and far-field). More explicitly, if we make use of the vocabulary previously introduced, we will describe separately; on one hand Induction and Influence systems and on the other hand those involving the wave propagation.
Distant actions such as conceived by Newton, can be expressed essentially through the force idea. For Newton it was mainly a matter of gravity those effects can be seen at considerable distances. Electrical and magnetic forces discovered independently in the antique world have revealed, after the meticulous work of Coulomb and later on the one of Ampère, similar decreasing laws[1], identical to the one for gravitation and differing only on a scale factor. This proportionality coefficient is in favor of electrical forces, it is huge at the particle level[2]; however we only see small distant effects of these forces at our human size, let's see quickly why.
For gravitation the exclusively attractive effects of every elementary[3] mass add themselves and eventually act on the universe as an all. In the electrical case, the force that a charge exerts on another one depends on the sign of the charge. If, in a given volume, a balance between positive and negative charges and a balance between currents circulating in opposite directions are reached, the resulting force at some distance is very small. In the mathematical frame, the electric and magnetic fields take the form of a multipolar structure and their decreasing rate with distance is as rapid as the cancelling charges and currents are numerous and closely spaced.
The electric neutrality observed at large scale, the absence of magnetic monopoles and the random distribution of magnetic moments in ordinary matter, explain that these forces are only measurable at short distances. This short range is nevertheless relative, for instance solar protuberances are bent by the magnetic field of the star over distances ranging in hundreds of thousands kilometers. We will show in the following, but this should already seem intuitive to the reader impregnated with the relative distance idea, that the range will mainly depend on the size of the electric or magnetic dipoles involved.

[1] In the magnetic case one has to consider virtual magnetic monopoles because we only see dipolar structures in the real world.
[2] The gravitational force between the proton and the electron of the hydrogen atom is about 10^{40} times weaker than the electrical attraction bond.
[3] All masses are positive and attract themselves; even antimatter has a positive mass.

The electrical "miracle"

All the forces considered up to now follow the same decreasing rate with distance. However, besides their relative intensity compared to gravitation, electromagnetic forces stress a subtle conceptual issue. If it's obvious for anyone that important masses can be progressively constituted by an accretion mechanism of small bodies attracting themselves mutually, the situation is very different in the electromagnetic domain because charges of the same polarity repelled themselves.

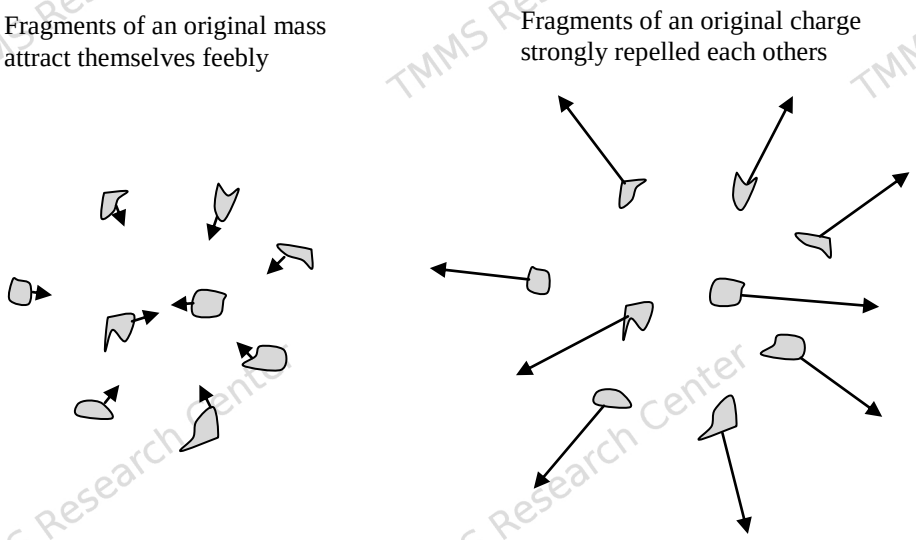


Fig.1: A fundamental difference between gravitation and electrical forces

For instance if one tries to constitute a very large electric charge he will have to accumulate elementary charges that will be repelled more and more strongly as the main charge is progressively built. In practice, as soon as an unbalanced electrical charge is reached, even if this charge is extremely small compared to the total amount of charges present in matter, charges are repelling themselves so strongly that they started to migrate on areas situated on opposite farthest sides of the object one is trying to charge. If one increases even more the charge, some electrons or ions are then ejected in the gas or vacuum surrounding the object. It is then possible to realize relatively large dipoles but with charges infinitely small compared to those present in the corresponding matter. It is this mechanism that explains the electric neutrality observed on large scales[1].

Let's explain a little more matters by considering now the microscopic side. Let's try to imagine one electron or one proton through classical concepts. Let's assume that we want to realize a material ball bearing on its surface the elementary charge given by Millikan's experiment: $e = 1{,}6.10^{-19}$C. To realize such a charge by bringing smaller elements from large distance, one has to realize a mechanical work and then to bring some energy to the system. This energy is larger and larger if the charged ball is smaller in size[2]. By energy consideration it is however possible to define a minimal size that the electron should have in a classical world. Einstein told us that energy and mass are equivalent so to get this limit we set that the electromagnetic energy should at most equals the electron mass[3]. This enables to define what

[1] Besides the fact that the observed Universe is globally neutral

[2] Note by the way that no one has already succeed to show an internal structure for the electron which is then considered as the very prototype of elementary material particle.

[3] Mathematically one set : $eV=m_ec^2$

is usually called the classical radius for the electron; a practical value of about r_{ec}=2,8.10^{-15}m is obtained. It is then possible to compute the electric field at the electron skin level, one finds E=1,6.10^{9}V/m, then more than a billion volts by meter. We can immediately get the repulsive forces at the electron surface level, expressed in terms of pressure one finds P_e=114Bar. It is then a miracle that the electron doesn't explode under the effect of this internal stress. We deduce that the electron is not constituted of ordinary matter and that in its core arise non-classical phenomena[1].

The electron classical radius set the limit where classical concepts should be replaced by something else. The reader will not be surprised to learn that the atom nucleuses have sizes in the range of this transition value. It results that the inside of the nucleus cannot be understood outside these new concepts. On the other hand, electronic orbitals, as many other chemical phenomena, can be explained, at least to some extent, in the classical frame[2]. We know these days that, sorted by decreasing intensity, atomic structures, chemical bounds and numerous other effects as for instance surface tension can be explained at least to some extend by this background attraction/repulsion game between distant charged elementary particles. In particular contact forces could be interpreted as repelling forces between electronic clouds of the facing atoms and molecules in the involved materials.

Forces do not explain everything

Forces are one of the key fundamental concepts of classical mechanics and are tightly associated to quantum theories even in a slightly different meaning. In the classic frame they are self sufficient to describe instantaneous[3] mechanical actions at short distance but are insufficient to treat the case of action that take a certain amount of time to reach their objective. In the later case one has to use the propagation idea and the associated concept of waves.

Far before Newton, ancients know that the sounds where propagating over long distances as waves on the surface of the ocean. Nowadays we know that the light coming from the sun and far stars, and more generally all material particles, show a wavelike character. In the technological field, using electromagnetic waves concentrated in beams enable to transfer energy over considerable distances.

One specific difficulty that we will meet in the wireless energy domain is the amalgamation of the two possible transfer modes: through a force at short distances or waves at larger ones. This misleading merging comes, as we are now going to explain, from an improper extension of the wave-particle duality concept.

[1] Note that the building of a mass by accretion releases some energy, reversely to constitute an electrical charge you need to provide energy. Despite their similar formal descriptions, gravitation and electrical forces have very different behaviors.
[2] If quantification rules are taken into account one obtains semi-classic approximations.
[3] These actions are not necessarily perfectly instantaneous but could be treated as such with a sufficient accuracy in the frame considered.

The modern unification of the two concepts

The two concepts of force at a distance and waves could be linked. Propagation in a continuous deformable media can be seen as the transmission from place to place of a stress under the effect of a local strain. From this point of view the forces generate the waves.

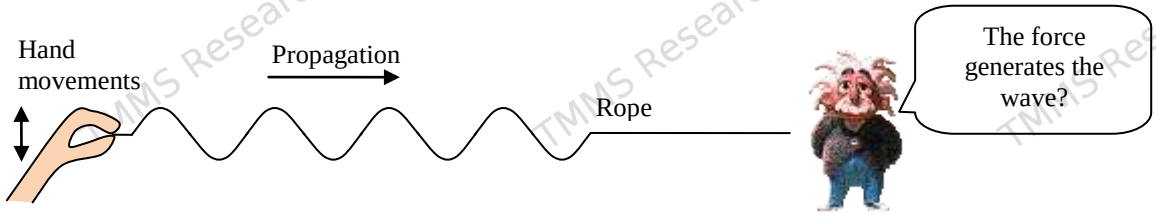


Fig.2 Génération d'une onde par une force oscillante

Inversely, the impact of a wave on a material surface with a density higher than the propagation medium produces a backward force on the wall when the wave is reflected. In this case, it seems that it is the waves that create the forces.

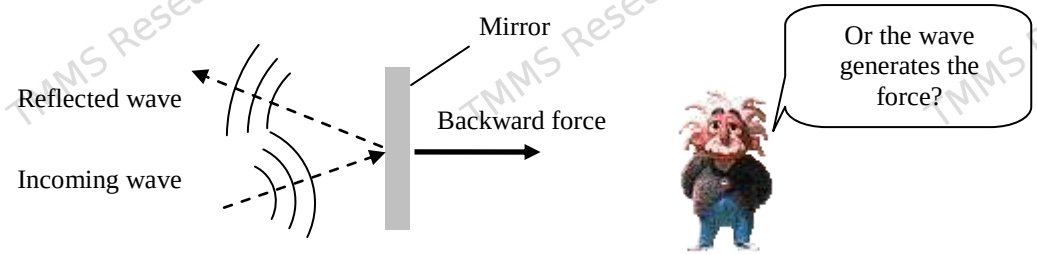


Fig. 3: The backward force resulting from the radiation pressure on a reflecting wall

It looks like if waves where carrying some momentum as a particle of matter does. Through this artifice it is sometimes possible to forget somehow propagation of waves and to come back to classical problems of trajectories and collisions. However this is only possible in the frame of what is called optical geometry; that is for waves propagating in strait lines. Such situations are obtained only for objects presenting flat surfaces at the wavelength scale or when one considers the far EM field of a given source. Many other situations, such as the ones producing interferences or diffraction, that do not fulfill the preceding requirements, still require a more elaborated model based for instance on the concept of a continuously deformable media.

The modern idea of interaction between two objects or two particles is a way to unify various types of interactions. However it is only a generic title that hides a diversity of practical implementations. Two persons can interact in various ways (by direct contact, by talking, by mail…), physical objects and particles can do the same. In the standard model of modern physics, fundamental particles can interact through four different forces: gravitation, electromagnetic force, weak nuclear force and strong nuclear force.

We will consider here only the electromagnetic force that dominates to a large extent at our human scale and that we know how to manipulate to produce such wonderful applications.

The reader will surely have remarked that in the standard model picture, all that was previously evoked: the electric and magnetic forces, the waves and propagation, are all summarized by a single expression: "electromagnetic force". We will now explain the origin of this expression and how it can come to be very restrictive.

Quantum mechanics interpretation issues

After the discovery of the quantum aspect of microscopic matter (existence of particles with perfectly defined masses and charges), as come the discovery of the quantification of the light, clearly observable in the photoelectric effect and more generally in atomic emission/absorption rays. However one needs to understand that it is not the fact that light is emitted on very specific frequencies that constitute the main aspect of the radiating field quantification but the fact that this light is emitted by indivisible packets of energy. A quantum guitar will not simply produce well defined frequencies as does a classic guitar, it will produce weak sounds in distinct packets. These packets of the electromagnetic field are called photons; they are the mediators of the electromagnetic interaction. They allow, according to theorists, to describe both far-field and near-field situations, although the near-field formalism is far more complex. It result the simple amalgam: electromagnetic force = exchange of photons, end of the story.
However the situation is not as simple as some promoters of the QED theory suggested[1]. To paraphrase this idea we may use a Mark Twain's quote: "*Facts* are stubborn things, but *statistics* are more pliable". Even if the quantification principle of the electromagnetic field is not to be discussed, several types of photons are introduced in QED depending on situations. Besides, if indisputable results so precisely confirmed by experiments are available, QED lacks of a clear physical interpretation of the near-field nature, this leads some specialists to reductive or even dogmatic positions.

To illustrate some common incoherencies, let's take the case of the electron picture in the quantum frame. This particle is at the same time point-like, otherwise how to explain the fact that it has no substructure, and extended, if not, how to explain that a single particle crossing the two slits of a device can produce interferences. This fundamental issue is hidden behind the unclear wave-particle duality. Up to this point nothing new, but here we come. In the same time QED and more generally the standard model resolve the electron into two different elements, the central point-like particle and the wave traveling with it, seen as a cloud of virtual particles. Then if we emphasize a little, some quantum physicists will say that it is not the electron that interferes with itself but the virtual cloud structure of its near-field that travels along with it. Then in the wave-particle duality, the wave is not really a part of the object. You should admit that all this is a little nebulous.

[1] According to Feynman all interactions between electrical particles eventually ended to a simple exchange of photons.

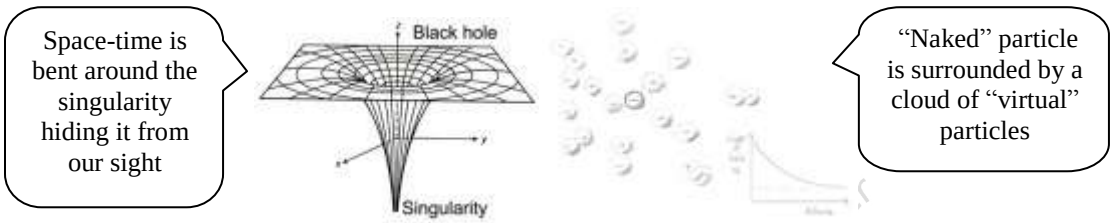


Fig.3: Classical and quantum picture of a central singularity

Once again, quantum formalism is not to be blamed, it is its physical interpretation such as commonly presented that is often oversimplifying and reveals a lack of a clear picture of the underlying processes.

The idea in this pages is not to make the same mistakes by trying to introduce by force in a dogmatic manner the photons in the near-field but to choose without any preconceive idea, concepts that are the most appropriate to describe the non-radiating near-field situation. We will see that the idea of a continuous fluid will often come back and we will explain how it can help to solve the point-like/extended conflict. The idea of a continuous medium is by the way not incompatible with the idea of quantification; a fluid may appear continuous at a certain scale and quantified at another one[1].

A fully empirical approach

In the proposed empirical approach, we will draw attention, starting from simple practical elements, to a fundamental breaking appearing formally inside the Maxwell's equations frame. We will see that the physics of the near-field is very different from the one of the far field; this at the same time because of its mathematical specificities and by the manner it should be conceived. In particular the idea of a "whole non-divisible" will emerge opposed to the "locally separable" concept. The later being the central core of the standard model. We will make strong analogies between the behavior of electromagnetic field and material fluids that present the same double conceptual scheme: near-field/far field.

In order to fight against the raising wave dogmatism we will use the formerly proposed vocabulary, at the same time compliant with the historical context and not ambiguous in its meaning. This approach will be mainly based on the rediscovery of classical concepts, according to us too quickly discarded during the last century.
For a few readers this will be an occasion for a deeper thinking on the pertinence of these past choices and on the directions that possible alternatives may follow.

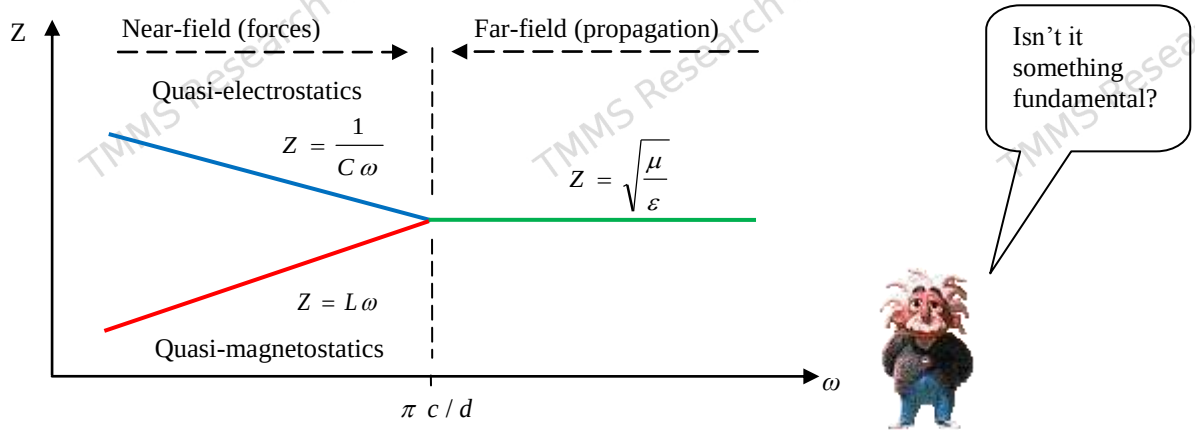
[1] Quantification does not appear necessarily only at small scale; for instance in the case of a fluid heated by its lower side, one sees macroscopic convection cells organized in a crystal-like regular pattern.

To summarize: a quasi-contact at a distance picture and its metaphysical consequence

Material contact has no real meaning, what seems however very tangible and solid is only the result of repulsive quasi-static force between distant atoms or molecules. Non-radiating near-field devices are of the same nature and involve the same physics. However they do it on distances much larger. This immateriality of the contact, being openly shown, is not going without raising questions more metaphysical than physical on this idea of contact at a distance and, in a way a little more applied, on the question of the spatial extension of electrons and more generally elementary particles.
If one admits that the particles are extended, new questions arise: up to what extent, what are they made of, and how to explain that they make an inseparable whole?

In the following we will propose, beside the classical formalism and working models, some partial answers to these fundamental questions along with illustrations based on very simple physical models.

In the last article dedicated to this general conceptual approach, the reader will find more quantitative and qualitative elements, based on the Maxwell's equations empirical frame, which will clearly reveal this fundamental bifurcation between the near-field and the far-field.



The magnetic/electric bifurcation