Instantaneous electrodynamic potential with retarded energy transfer

H. Aspden
Department of Electrical Engineering, University of Southhampton, Southhampton SO9 5NH, England
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Relativistic electrodynamic (ED) derivations of the Lorentz force can be questioned if, as for the weak interaction, the hadron-hadron ED interaction differs from the lepton-lepton ED interaction. The argument raised by C. K. Whitney in a recent *Hadronic Journal* paper is here developed in a radically different way. By deriving the Neumann potential from the Coulomb law, assuming instantaneous action but retarded energy transfer in a zero-point energy background, it is shown that the hadron-hadron ED interaction should be anomalous. This is deemed to be relevant to the experimental issues raised by Whitney.

I. INTRODUCTION

In the theories of fundamental physics there is nothing more basic than the question of how two electric charges interact when in motion. This is something that ought to have been completely resolved when the properties of the electron were discovered. It is a phenomenon prevalent everywhere in the universe, reproducible in the laboratory, and yet we still have no certain knowledge of how two discrete charges interact. We do not even have an empirically verified formulation for the ED force interaction at the particle-particle level, as opposed to the particle interaction with a closed current circuit.

The question is first clouded by the problem of what is meant by "motion," because motion is relative and has to be measured relative to some frame of reference, even if that is seated in one of the charges. It is no wonder, therefore, that the inconclusive struggles in the 19th century of pioneers such as Ampère, Weber, Helmholtz, Neumann, Clausius, and Maxwell became clouded in even greater mystery when the Michelson-Morley experiment upset the classical picture of the ether reference frame. Today the Lorentz force, which is a contracted electrodynamic force law, is used in preference to those of Ampère and others. Relying on the Lorentz-force formulation, Trouton and Noble[1] in 1903 performed an experiment aimed at detecting the earth's motion through the ether. It gave a null, consistent with the null of the Michelson-Morley experiment, and immediately Lorentz[2] in 1904 presented his famous transformation theory. Then Einstein[3] in 1905 took up this electrodynamic problem in the context of relativistic distortion of reference frames.

Lorentz and Einstein compounded the problem; they did not resolve it. The Trouton-Noble experiment ought really to have been seen as proving that the Lorentz force was not the true force representing the electrodynamic interaction of two discrete charges in motion. What was observed, namely that any force between parallel moving charges must act directly along the line joining the charges, was either a disproof of the Lorentz force law or evidence of no motion through the electromagnetic reference frame. Nor was it realized that the null of the Michelson-Morley experiment was attributable to a "drag" of the standing-wave energy in the optical interference. Instead, scientists thought in terms of "ether drag," meaning a drag of the applicable reference frame. The latter notion could not be digested in a wholly satisfactory physical context, so the appeal of the mystique of Einstein's theory came to the fore. This has left us with all the old uncertainties concerning the true law of electrodynamics.

So far as this author is concerned, the whole fabric of the theory of relativity is of secondary importance and is indeed somewhat irrelevant if it cannot resolve the primary question concerning the electrodynamic interaction. However, owing to certain experimental advances in electrodynamics, particularly involving ions of hadronic form, it becomes opportune to raise the fundamental theoretical issues, even though this involves an open challenge to relativistic doctrine.

II. HADRON ELECTRODYNAMICS

It is realized that little can be achieved by theoretical formulations devoid of new experimental relevance. Relativity and quantum electrodynamics are too well entrenched in the world of theory. Accordingly, the interest has to center on anomalies found in experiment and an approach which is relevant to those anomalies. With this and the classical idea of "vitreous" and "resinous" electricity in mind, we will seek to distinguish between the proton-proton ED interaction and the electron-electron ED interaction. The simple issue is whether the leptonic nature of the electron implies electron currents having characteristics differing from those set up by currents produced by the nonleptons such as the proton. If there is a discernable difference, then we have reason to believe that Einstein's theory is lacking so far as its relevance to electrodynamics is concerned.

The classical notion of the two kinds of electricity constituting a current by their motion in opposite directions, an idea which had sound relevance to the form of electrodynamic law, antedates the experimental discovery of the electron. However, it fits remarkably well with the picture of current flow by an electron that interacts with a virtual electron-positron field. If the recurrent creation and annihilation of the charge pairs involves the primary electron in the annihilation process to leave a newly constituted electron in the forward field, then that is a current flow process. The current comprises the equal counterflow of opposite charges, exactly as was assumed in the classical Fechner hypothesis to advance our understanding of electrodynamic law.

Given that a proton or other type of hadron could not engage in this pair creation activity in the field, we clearly have a means for testing the Fechner hypothesis. Do currents set up by protons and acting on other protons actually comply with the same electrodynamic laws as the electron-electron interaction? It is here that the recent paper by Whitney[4] opens the debate. She refers to the research of Professor Graneau, who has found evidence of anomalous electrodynamic forces some thousand times greater than expected from conventional theory. This research involves setting up current flow in liquids under circumstances where the charge is carried by ions and can be said to be seated in hadrons.

From this there is purpose in our reconsidering some aspects of the basic theory of the electrodynamic interaction, and this paper does that in a novel way. Whitney is quite justified in challenging the orthodox use of the Lienard-Wiechert potentials, and her continuing research warrants close attention, but equally there is something to be gained from taking a very simple stance in the study of this problem.

Before engaging in theoretical discussion it is appropriate to mention by way of record two experimental points. Firstly, dating from the 19th century, the experiments of Foppl[5] reported in 1886 and those of Nichols and Franklin[6] based on the unitary-current-carrier hypothesis gave null results. The latter tests were deemed to be ten million times more sensitive than needed to detect a state in which current in a moving wire is solely due to charge carriers of the same polarity. It is not understood why we have come to regard the electron as the sole carrier in motion in metal conductors in view of this experimental background. Secondly, in the light of the Graneau experiments on anomalous axial electrodynamic forces set up by ion flow in liquids, as referenced below, the author has performed an experiment aimed at detecting the force between two elementary portions of a current produced in a salt solution. However, the author found no discernable forces along the current axis. These latter experiments, reported in Ref. 7, differed from those of Graneau in that they involved steady-state current flow set up by a potential of a few volts, whereas Graneau used discharges powered by several kilovolts and very much higher transient current pulses. The author has questioned some aspects of Graneau's findings,[8] owing to the problems of inductive EMF and its bearing upon the axial force, but this does not detract from belief in the anomalous effects. Indeed, since Ref. 7 was published, the author has come to suspect that there could be a threshold effect when hadronic charges in an electrical discharge are driven by an electric potential of the order of 2 kilovolts. It is beyond the scope of this paper to justify this, but essentially there is reason for thinking that the energy available from such a voltage could free a hadron that is locked into the vacuum field structure of the author's theory.[9] In effect, a hadron that is locked in a site in such a field structure is like an electron neutralizing a positive hole in the Dirac theory.

III. RETARDED ENERGY TRANSFER

As Whitney[4] notes, the belief that the electric field lines emanating from a charge in uniform motion move bodily with that charge with no distortion is compelling. It is consistent with Newtonian instantaneous action at a distance. She argues, however, that the field lines are curved, bearing also in mind that there are relativistic problems with the Newtonian action-at-a-distance concept.

In this paper we shall explore how far we can proceed by retaining that notion that the Coulomb action of electric charge is an instantaneous action. Firstly, as is now well known, there are indications from experiments to test quantum theory that interactions at superluminal speeds are a reality. We are not relying, therefore, on a Newtonian hypothesis. Secondly, action at a distance is desirable as a means for understanding how forces can be in true balance, acting along the line drawn between the two charges. In this regard, Burniston Brown,[10] in his criticisms of the theory of relativity, has evolved a theory for what he terms "retarded action at a distance."

Both Whitney and Burniston Brown realize that one cannot progress from the Coulomb law and its prospective instantaneous interaction to a law of electrodynamics without in some way introducing the speed parameter c. This implies retardation of some kind. Ignoring relativistic transformations and contraction of reference frames, one has then three choices. There is the retarded-potential Lienard-Weichert route. There is the Burniston Brown proposition that the direct action force is subject to time delay. Alternatively, there is the following proposition that there is instantaneous interaction which can cause a charge to lose or acquire energy spontaneously, but by an exchange with the zero-point energy background, pending energy adjustments between the localities of the charges as the zero-point energy background recovers its equilibrium.

The last proposition lends itself to an extremely simple analysis having immediate relevance to the classical treatment of the subject.

IV. ANALYSIS OF THE TWO-CHARGE INTERACTION

Firstly, we consider the mutual interaction of two charges as if they existed in isolation from the rest of the universe.

By symmetry two such charges of equal unitary magnitude, whether of like or unlike polarity, will both absorb or emit energy quanta in equal amounts and simultaneously in their exchanges with the zero-point energy background. Such exchanges involve background radiation, for which the speed c is the dominant factor in scaling the relationship between the energy transfer rate and the radiation momentum force produced. Let E denote the energy exchange at either of the charges e or e', separated by the distance r.

The forces acting on the charges can then be determined as the direct mutual and instantaneous Coulomb force ee'/r^2 offset by the radiation reaction force $(1/c)\,\delta E/\delta t$. Now, we know that $2E$ is the background energy component that accompanies this interaction. It is energy which has been borrowed from or added to the radiation field, disturbing its equilibrium, from which it seeks to recover. Suppose that at e and e' the energy E has been supplied to augment the kinetic energy of the charge. There is a deficit energy in the background centered on e and e'. Somewhere in the electric field system that sets up the Coulomb force there is energy that has been shed to the background owing to the change of the separation distance r. Now, rigorous analysis by the author[11] as to the disposition of that energy in the Coulomb field shows that, as viewed from either charge, there is no net Coulomb energy within the sphere bounded by the range r from either charge. It follows that any energy transfer between that Coulomb field and the individual charge locations involves transfer over a mean distance equal to r. Radiation in the electromagnetic background field will traverse that distance in a time τ of r/c. Thus we can formulate the energy $2E$ in transit as:

$$2E = \frac{\tau \delta P}{\delta t}, \tag{1}$$

where P is the Coulomb potential ee'/r.

It is now very important to realize that E is never negative, so a reduction in P has to be treated as a positive rate of change in computing E from Eq. (1). Similarly, all components of the rate of change of momentum of the energy E have to be assigned a direction that amounts to a reaction opposing the Coulomb force. Indeed, the radiation reaction arising from transverse relative motion has to be separated from the radiation reaction resulting from relative radial velocity in setting these directions. This explains why the sign in the next equation is positive rather than negative.

The offset force, or electrodynamic force, acting on e or e' is then determined as $1/2c$ times the time derivative of $(r/c)\,\delta P/\delta t$. Since P is a simple function of r, we then readily obtain

$$F = \frac{1}{2c^2}\left[\frac{ee'}{r^2}\left(\frac{\delta r}{\delta t}\right)^2 + \frac{ee'}{r}\frac{\delta^2 r}{\delta t^2}\right]. \tag{2}$$

This simplifies if we write the relative radial velocity $\delta r/\delta t$ as u and the relative radial acceleration $\delta^2 r/\delta t^2$ as v^2/r, where v is the relative transverse velocity. The result is

$$F = \frac{ee'}{2r^2}\left(\frac{V}{c}\right)^2, \tag{3}$$

where V is the overall relative velocity between e' and e.

Note that we are not considering inertial conditions. No mass is involved in this analysis. The analysis merely involves two charges moving at steady velocities. The variation of r can be regarded as by transient reference to a nonrotating frame centered on e and in which the velocity V of e' is measured. In such a frame the line drawn from e to the position that e' occupied at a time prior by a short period t will have a constant length L for the transient moment of analysis. Let ϕ be the angle between V and L. Then

$$r^2 = L^2 + (Vt)^2 - 2LVt\cos\phi \tag{4}$$

with V and L constant. Upon differentiating twice with respect to time, this reduces to an expression which justifies the step from Eq. (2) to Eq. (3).

The expression in Eq. (3) corresponds to the force produced by the electrokinetic potential assumed by classical physicists as a basis for deriving the Neumann potential. So far as this author is aware, this electrokinetic potential term has never before been deduced directly from the Coulomb force. Hitherto, it has been introduced by assumption, owing to its analogy with the kinetic energy of electromagnetic mass. It is believed, therefore, that the argument presented above is an important advance, especially in view of its intrinsic simplicity and its direct relevance and applicability to electromagnetic problems.

By supposing that there is an electrodynamic frame of reference in which current elements comprise two charges $+e$ and $-e$ moving at velocities $\mathbf{v}/2$ and $-\mathbf{v}/2$, respectively, the interaction with a charge e' moving at $\mathbf{v}'$ will, from (3), cancel terms other than those in $\mathbf{v}\cdot\mathbf{v}'$. The resultant force expression will be a scalar product of the two vectors $\mathbf{v}$ and $\mathbf{v}'$, given by

$$\mathbf{F} = -\frac{ee'}{r^3}(\mathbf{v}\cdot\mathbf{v}')\mathbf{r}. \tag{5}$$

Here $\mathbf{r}$ in the numerator has vector character to signify that the force acts in the direction of $\mathbf{r}$.

It is seen, therefore, that this simple argument about instantaneous Coulomb interaction with energy exchange involving the zero-point background radiation field has given us a definite electrodynamic force closely conforming with that derivable from the Neumann potential. However, the argument relies on at least one of the interacting charges satisfying the Fechner hypothesis and so being a lepton. Otherwise, the force is directly specified by Eq. (3).

V. ANALYSIS OF THE MULTICHARGE INTERACTION

To proceed from (5) to deduce the full electrodynamic law which includes the Lorentz force as a special case, we must now consider additional forces that stem from the extraneous mutual interactions set up by the presence of other nearby charges in motion. These can affect the symmetry of the primary interaction between two charges. In effect, the expression (5) when integrated for all interactions remains the basis for computing the net electromagnetic energy involved, but on an elemental basis in permitting superposition it needs supplementing by forces of a virtual nature in the sense that they do no work yet redirect the action.

In short, we will bring in the mutual induction effects to encompass Faraday's induction within an overall force expression that includes the steady-state formulation of the Lorentz force.

The analysis has been presented elsewhere,[7] but in summary form it consists of saying that the full force expression for the electrodynamic action of e upon e' includes the term (5) plus two other terms **A** and **B**. The term **B** arises from the fact that if e' loses or gains kinetic energy, then it must be subject to a force component lying in the direction of v'. Should the vector $\mathbf{r}$ from e to e' change, this means that work is done at the rate $\mathbf{B}(\mathbf{v}'\cdot\mathbf{r})/r$. The problem then is that we have already said that no work other than that associated with (5) is involved. It follows therefore that there has to be a compensatory effect and hence the need for the **A** force component.

There is nothing to be gained by writing **A** as $-$**B**, as that denies the induction process that we know exists, so we look at the alternative. Suppose that the **B** force really does all the work and that it is the **A** force that balances the expression (5). Then the **A** force does work at the same rate but in the opposite sense to the force in the expression (5). For this to be so, the force **A** must act in the direction **v** so as to form a component $(\mathbf{v}\cdot\mathbf{v}')(\mathbf{v}'\cdot\mathbf{r})$ when resolved along $\mathbf{v}'$. Evidently, **A** is of the form $(\mathbf{v}'\cdot\mathbf{r})\mathbf{v}$. Then, to find **B**, we take note that **A** plus **B** can do no work collectively as **r** changes. When these two force components are resolved in the direction of **r**, their sum is zero. It follows that **A** is proportional to $(\mathbf{v}'\cdot\mathbf{r})\mathbf{v}$ and so has a resolved component proportional to $(\mathbf{v}'\cdot\mathbf{r})(\mathbf{v}\cdot\mathbf{r})/r$, so **B** must be proportional to $-(\mathbf{v}\cdot\mathbf{r})\mathbf{v}'$ to give the corresponding expression $-(\mathbf{v}\cdot\mathbf{r})(\mathbf{v}'\cdot\mathbf{r})/r$.

By rigorous argument we are led therefore to a unique electrodynamic force law, the last term of which is operative as an instantaneous interaction and has the form:

$$\mathbf{F} = \frac{ee'}{r^3}\left[(\mathbf{v}'\cdot\mathbf{r})\mathbf{v} - (\mathbf{v}\cdot\mathbf{r})\mathbf{v}' - (\mathbf{v}\cdot\mathbf{v}')\mathbf{r}\right]. \quad (6)$$

The middle term in this expression is the induction term. It integrates to zero if the charge e is averaged around a closed circuit, because for every positive elemental component of $\mathbf{v}\cdot\mathbf{r}$ there is an equal negative component. Thus in the steady-state action of a circuital current on an isolated charge e' we are left with the two outer terms in (6). These contract into a single vector-product term to give the Lorentz force.

It is curious that Maxwell came very close to discovering this form of law as he presented one of the form in which the middle term is positive in his famous treatise. A reference of more convenient form, however, is the account by Whittaker,[12] where vector expressions such as (6) are presented. Whittaker deduces the same law with the middle term positive, on the assumption that linear action must balance linear reaction, whereas an out-of-balance couple is permitted. What the classical theorists failed to realize in their empirical studies was the fact that the law is a component force law, meaning that e' is subject to numerous other effects from similar charges e in the environment, effects which can include whatever charges exist as part of the vacuum state. This means that the force law could develop out-of-balance forces, as indeed does the Lorentz force, but in a way that can account for energy transfer by induction. The Lorentz force excludes energy transfer by induction by restricting attention to the force component perpendicular to the motion of e'.

VI. GRAVITATION

Although this paper has been written in the light of Whitney's criticism of the retarded-potential methods, it is opportune in that it connects with prior work concerning gravitation, already of record in the *Hadronic Journal*.[13]

The problem of gravitation, so far as unification with electrodynamic field theory is concerned, is the derivation of an inverse-square type of force law for actions between mass separated by a constant distance. The retardation effects are problematic if one tries to use retarded potential theory. Retardation does come into play in planetary motion around the sun, where the elliptical orbit involves continuous energy transfer between sun and planet. That accounts for the anomalous perihelion advance. However, so far as the basic action of gravitation is concerned, this arises, in the author's theory, from a concerted synchronous cyclic motion of vacuum charges set up by the presence of matter in an oscillatory vacuum lattice. All such charge is moving mutually parallel at any instant. Therefore, the first two terms in the bracket in (6) cancel to leave (5). This is a true inverse-square-of-distance law with instantaneous action. Hence the nature of the gravitational interaction is fully justified. The real issue in proving that this is a true explanation of gravitation concerns the derivation of the constant of gravitation G, and it is this that is outlined in Ref. 13.

The author also points to the supporting evidence on the underlying gravitational theory presented in the recent *Hadronic Journal* paper [14] that discusses the missing atoms, technetium and promethium.

VII. PROTON ELECTRODYNAMICS

The most important proposition in this paper is that emerging from the way in which the force corresponding to the Neumann potential has been deduced. The Fechner lepton hypothesis consideration was vital, but the essential point was that only one of the interacting charges had to be necessarily leptonic in form to deduce the Lorentz force law.

This raises the issue of whether the hadron-hadron interaction satisfies the expression (3) or the Lorentz force law. If a magnetic field produced by a proton current acts on protons in motion, will that proton be deflected according to the Lorentz force law? If not, then that might well afford evidence supporting the basic theory in this paper. Otherwise, to retain this theory, the proton must also migrate by involving proton-antiproton activity in its field, which is a proposition that will not be easy to entertain.

The real question, therefore, is whether we have evidence of any anomalous effects when a self-contained circuit conveys current by protons or as hadronic matter in heavy ions. Protons moving along a plasma discharge and not having relative motion will not develop an electromagnetic mutual pinch, as do electrons. What is deemed to be a neutral plasma can therefore favor a transfer of current from the electrons to the protons. Now, anomalies of exactly this kind are reported by Sethian *et al.*,[15] where energy transfer from electron to proton occurs on a scale 1000 times greater than normal theory predicts.

Similarly, there are anomalous electrodynamic effects reported by Graneau and Graneau[16–18] when strong electric currents are discharged through water. Undoubtedly, as Whitney[4] suggests, this research is relevant to a deeper understanding of electrodynamics along lines that break faith with the Lorentz law. However, a discussion of that lies outside the scope of this paper. From the viewpoint of a direct hadronic-type effect it is more pertinent to mention the Sherwin-Rawcliffe experiment, as reviewed by Phipps.[19] In this experiment atomic nuclei having a high degree of asymmetry in their proton charge distribution were accelerated to high speed to see if their intrinsic energy was a function of orientation relative to their direction of motion. Using the Lorentz force law, much as Trouton and Noble[1] did in their 1903 test with charged capacitors transported with the earth, one concludes that the experiment should have given a very positive effect. A null in the Trouton-Noble experiment signified support for relativity and/or invalidation of the Lorentz force. However, a null in the Sherwin-Rawcliffe experiment is essentially a test of the Lorentz force, assuming our picture of the multiproton atom is correct. The experiment gave a very definite null, a result which is consistent with the force deduced in Eq. (3). There is no relative motion between the protons in this test.

The conclusion from this argument is that we have good reason for suspecting that the electrodynamic hadron-hadron interaction breaches the Lorentz force law. The Lorentz force law as deduced from Einstein's theory is unable to distinguish between the behavior of hadrons and leptons. Hence there is something very interesting about hadrons in the electrodynamic context. The very roots of relativity theory can be challenged on this issue. Furthermore, in presenting the formal derivation of the basic expression that leads to the Neumann potential for leptonic interaction, the spinoff has been an insight into how the form of a law of gravitation can be reconciled with electrodynamic theory. The essential step is to break away from the use of Lienard-Weichert potentials and consider instantaneous actions that borrow energy from the background zero-point field.

It has been suggested to the author that proton-proton scattering supports the view that there are electromagnetic interactions between protons. This is not the issue. The real question is whether the force law given by Eq. (3) applies or whether the Lorentz force law holds true for such proton-proton interactions. Inasmuch as we have no direct experimental evidence of any determination of the true law of electrodynamics, whether we think of collisions involving isolated protons or isolated electrons or both, the question is open. It is time that it was resolved, and a rigid adherence to the textbook treatment based on retarded-potential theory can serve only to retard progress.

A crucial question that experiment alone can help to resolve is the physical nature of the operative electromagnetic frame of reference. This may be the frame in which the lepton creation and annihilation occurs and so the governing one for the Lorentz force and the law of electrodynamics given by Eq. (5). The frame may also be adaptive in the sense that hadronic structures might locate and share the motion of their own frame in the above sense, whereas the underlying expression (3) applies more generally. This is why the author referred to the possibility of a hadron being freed from the vacuum field lattice by a 2-kilovolt potential. Conceivably both the Lorentz laws and the expression (3) might apply to partial extents in certain situations. The latter concerns relative charge motion only and so has the universal context.

Finally, it is appropriate to mention that recent detection of motion through the ether by Silvertooth,[20,21] as discussed by the author,[22,23] has bearing upon the electromagnetic energy transfer process. It is as if interfering waves brought into head-on collision from the same laser source deploy their energy to set up standing waves that transport the energy with the speed of the apparatus. This forces an in-phase modulation which in turn forces the countermoving wave components to have a speed referenced on the apparatus. However, as Silvertooth finds, to the extent that energy is transported to the detector that scans linearly along the interfering beam path, the one-way waves that are associated with this appear to travel as if referenced on a preferred frame, because they modulate the standing wave along that path. In effect, in this experiment, which has sensed a 378-km/s motion through a preferred frame, we have two frames of reference for electromagnetic action. One is that of the hadronic matter of the apparatus itself. The other is the absolute space frame. Conceivably, research will show that the force expression (3), though strictly relative in its velocity relationship, will have some small related dependence upon this light-speed isotropy issue via the term in c. Should the Silvertooth experiment be confirmed by an accredited laboratory such as the U.S. National Bureau of Standards, we shall then realize that there is purpose in reverting to the electrodynamic scene as it stood when the Michelson-Morley experiment intruded. In a sense, this is what the author has done in presenting this paper.

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> Aspden's suggestion that a stream of electrons produces different magnetic effects than a stream of positive ions travelling along the path and conveying the same current is as novel as it is stunning. Yet I have reason to believe that he is right. Experiments have shown that an electric arc in water, in which the charge carriers are supposed to be electrons, causes an explosion while the same amount of current carried by ions in saltwater does not produce explosive forces. The time has come to check whether an electrolytic current generates the same magnetic field strength as a current through a copper wire.

Concerning this suggestion, it is important to keep in mind that the author's thesis is that the different magnetic effects must be sensed by the effect on hadrons (not electrons). The hadron-hadron or ion-ion interaction in the saltwater experiment may not set up the powerful electrodynamic interactions that are found for the electron-electron or electron-ion interaction.

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