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Unification of Gravitational and Electrodynamic Potential Based on Classical Action-at-a-Distance Theory.

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Summary. – By taking account of the different field distributions of electric- and magnetic-field energy and assuming that their collective potential asserts action-at-a distance forces, the equations of motion governing the electrodynamic action (Lorentz force) and the gravitational action (planetary perihelion advance) are deduced from the common and unifying equation of field potential.

Notwithstanding the successful application of retarded potential theory to practical situations in which circuital electron motion develops magnetic fields, there is increasing evidence of anomaly in situations where heavy ions convey current as part of the primary circuit (1,2). Forces some 40 000 times stronger than can be predicted from lateral-pressure effects due to pinch forces have now been measured for current discharge in liquids (3). This makes the paradoxical features of accepted electrodynamic theory assume a new significance and suggests the need for revision of ideas at the fundamental level.

The most direct way of overcoming many of the paradoxes is to revert to action-at-a-distance theory. The pre-acceleration and post-acceleration techniques advocated by WHEELER and FEYMANN (4) present many problems (5). It is desirable to relate cause and effect directly and assure that action balances reaction. Similarly, in a broader context concerning the problem of finding the unifying link between magnetism and gravitation, general relativity has been criticized for its failure to explain the concept of inertia. Mach's principle, which requires the inertia of a particle to depend upon the actions of remote stars, is hardly tenable, unless there are action-at-a-distance forces communicated directly between particles at their instantaneous positions in a

(1) H. ASPDEN: *J. Franklin Inst.*, **287**, 179 (1969).
(2) H. ASPDEN: *IEEE Trans. Plasma Sci.*, PS-**5**, 159 (1977).
(3) P. GRANEAU and P. N. GRANEAU: *Appl. Phys. Lett.*, **46**, 468 (1985).
(4) J. A. WHEELER and R. P. FEYNMAN: *Rev. Mod. Phys.*, **17**, 157 (1945).
(5) J. NARLIKAR: *The Structure of the Universe* (Oxford University Press, 1977), p. 190.

world devoid of retardation. Yet, the work of Gödel and others has shown that the spinning universes permitted by general relativity are incompatible with Mach's ideas ([6,7]).

There has been a proposal that there should be retarded action-at-a-distance ([8]), aimed at denying the existence of the field medium or ether as something separate from the interacting particles. However, one must have some physical reference frame for actions, if electromagnetic phenomena are to be fully explained. Accordingly, the author has been led to examine the scope for a theory in which there is action-at-a-distance coupled with retarded energy transfer. The field medium or ether is only relevant in such a discussion as a medium in which charge pairs are created by the usual quantum electrodynamic processes and, of course, as that elusive medium which somehow assures that energy quanta can transfer at the speed c.

The starting point from which the results presented here have emerged is the author's recent paper ([9]) discussing the anomalous doubling of the positron mass in an electron gas. This has pointed attention at spatial field distribution of energy.

The unifying principle to be discussed requires that force is an action of nonretarded potential, but that when interacting particles are in motion there is energy redeployment, so that some of the potential acts from a position which is a function of the motion. Electric (or gravitational) potential energy has a different spatial distribution over the mutual field than the concentrated kinetic energy of the individual particles. Dynamic energy, which we see as an independent kinetic state of the field (magnetic energy), is in transit between the two primary energy states. This dynamic energy itself asserts action-at-a-distance forces on a par with potential energy, but acts from its distributed position.

A factor k, crucial to the quantitative analysis, is introduced to account for the shorter action range applicable to dynamic energy. Analysis ([10]) shows that the spatial distribution of the electric field energy, in adjusting spontaneously as the two charges separate, will release energy which has, on average, to travel exactly the distance separating the charges in order to reach either charge. Conventional field theory analysis of the spatial magnetic energy distribution shows that, on average, the transfer distance is less than that for the electric energy release ([11]). In the vicinity of each charge the energy in concentric spherical shells varies at a linear rate with distance, so that its potential, which scales inversely with distance, is finite at each charge. However, in the dynamic state infinities in the potential arise if energy converges on the charge at uniform speed. A steady energy flow rate into a space cone having a charge at its apex will regulate the speed in inverse proportion to distance from apex, making the energy distribution in the cone vary linearly with distance and so assure that its potential is finite at the charge position. On this basis, the effective position of the dynamic energy from the viewpoint of its potential is midway between the charges, making $k = 2$.

Following the above introduction, we can now make the extremely simple rigorous calculation to obtain the classically derived force and potential equations.

We restrict attention to potential energy quantities expressed in units such that $P = 1/r$ denotes the primary potential of two interacting particles separated by the distance vector r and having velocities v, v' and relative velocity $V = v' - v$. The symbols $(V \uparrow r)$ and $(V \rightarrow r)$ denote the components of V parallel to r and at right

([6]) J. Narlikar: *The Structure of the Universe* (Oxford University Press, 1977), p. 169.
([7]) P. J. Brancazio: *The Nature of Physics* (MacMillan, New York, N. Y., 1975), p. 481.
([8]) G. Burniston Brown: *Retarded Action-at-a-Distance* (Cortney, Luton, England, 1982).
([9]) H. Aspden: *Lett. Nuovo Cimento*, **39**, 247 (1984).
([10]) H. Aspden: *Lett. Nuovo Cimento*, **25**, 456 (1979).
([11]) D. M. Eagles and H. Aspden: *Acta Phys. Pol. A*, **57**, 473 (1980).

angles to r, respectively. Similarly, relative acceleration parallel to r is denoted $(f \uparrow r)$. W denotes kinetic energy of the two interacting charges and E denotes dynamic energy (magnetic energy) in the transit state between P and W.

Energy conservation requires that

$$\mathrm{d}P/\mathrm{d}t + \mathrm{d}E/\mathrm{d}t + \mathrm{d}W/\mathrm{d}t = 0\,. \tag{1}$$

Writing $T = r/c$, a valid statement to second order in $(1/c)^2$ giving the energy in transit is

$$E = -\,(T/2)(\mathrm{d}P/\mathrm{d}t - \mathrm{d}W/\mathrm{d}t)\,. \tag{2}$$

From (1) and (2)

$$E = -\,T(\mathrm{d}P/\mathrm{d}t) - (T/2)(\mathrm{d}E/\mathrm{d}t)\,. \tag{3}$$

Substituting $P = 1/r$, the first term becomes $T(1/r^2)(V \uparrow r)$ or, replacing T

$$(1/cr)(V \uparrow r)\,. \tag{4}$$

By iteration, the second term in (3) is then found to be

$$(1/2rc^2)[(V \uparrow r)^2 - r(f \uparrow r)]\,, \tag{5}$$

which is

$$(1/2rc^2)[(V \uparrow r)^2 + (V \to r)^2]\,, \tag{6}$$

or

$$(1/2rc^2)(V)^2\,. \tag{7}$$

The force acting between the two particles is simply

$$F = -\,\mathrm{d}P/\mathrm{d}r - k(\mathrm{d}E/\mathrm{d}r)\,. \tag{8}$$

We now apply this result to the gravitational interaction and consider one particle as the heavy central mass of the Sun and the other as the relatively very small mass of a planet. V becomes the speed in orbit of the planet relative to the stationary Sun. The orbit is approximated by a circle of radius r. Thus $(V \uparrow r)$ is zero, leaving (7) as an expressione for E. Upon evaluation from (8), F is found to be

$$F = (1/r^2) + (3k/2)(V/c)^2(1/r^2)\,, \tag{9}$$

because, as is well established, for planetary motion we can regard $(V \to r)r$, the velocity moment (*), as constant. This is the condition for energy conservation with perturbed motion. When V in (7) is approximated by inverse relation to r, the differential of (7) introduces the scaling factor 3.

Equation (9) shows that if $k = 2$ the gravitational force acting on a planet is larger than the simple Newtonian expression by the factor $(1 + 3V^2/c^2)$. This causes the

(*) See appendix.

Newtonian law of gravitation

$$d^2u/d\varphi^2 + u = GM/h^2 \quad (10)$$

to become

$$d^2u/d\varphi^2 + u = GM/h^2 + 3GM(u^2/c^2) \quad (11)$$

in polar co-ordinate form (u, φ), where u is $1/r$ and h is velocity moment.

Equation (11) is precisely of the form derived from general relativity, as shown by WILSON [12], and it, therefore, accounts for the properties derivable from such an equation, notably the anomalous motion of the perihelion. Note, however, that this is only true if $k = 2$, as we have argued from the spatial energy distribution.

Considering now the application of the energy potential equation (3) in relation to the magnetic force, we find that (7) is identical to the potential assumed by MAXWELL [13] to derive the Neumann potential from a relative-velocity proposition. By using a classical-quantum-electrodynamic argument that all charge in motion is really constituted by opposite electricity in counter motion (the Fechner hypothesis), so that the potential becomes the sum of four individual potentials, he was able to make the expression linear in the separate velocity terms v and v'.

This same quantum electrodynamic base causes the term (4) to be zero, leaving (7) as the sole potential of the form

$$-(1/r)(1/c^2)(v \cdot v') , \quad (12)$$

which is a scalar-product expression.

The fact that $k = 2$ results in the related force component being double that measured empirically as the force needed to separate two current circuits at steady currents. However, this supports the field reaction theory needed to explain other anomalies, including positron mass doubling in a reactive electron environment [9]. It was there (ref. [9]) shown that the magnetic energy stored in the static field has the form of a centrifugal potential or kinetic energy of reacting field charge in helical motion. It works out that the diamagnetic reaction exactly cancels half of the primary field action and generates an effect which halves the mutual force between the primary charges of the electrodynamic interaction.

It remains to derive the Lorentz force from the Neumann force term $-(v \cdot v')r$ which, when divided by r^3, gives the force between two unit electromagnetic charges. Note that the external field does, as we have seen, exert forces which moderate the interaction between the two charges. Such reaction forces are part of the total mutual interaction and so cannot develop angular momentum. They must act on the charges without affecting their relative velocity, except to the extent of exactly halving the primary action, as just mentioned. Furthermore, we must give due attention to the fact that it is inconceivable that a particle having inertia can absorb or shed energy without its mass property being somehow involved.

The Neumann term $-(v \cdot v')r$ includes no mass parameter and so must itself be matched by an external force such that they together do no work on a charge moving in the direction v'. This determines the other force term as $(v' \cdot r)v$. Already, we then have the Lorentz force, because these terms together contract into a vector product

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[12] H. A. WILSON: *Modern Physics* (Blackie, London, 1937), p. 382.

[13] J. C. MAXWELL: *A Treatise on Electricity and Magnetism*, 3rd ed. of 1891; reprint by Dover Publ. (New York, N. Y., 1954), p. 480.

form which is the Lorentz force. It acts at right angles to the motion of the charge of velocity v'. There is a third force component to consider, one which accelerates this charge in a way which does work. Collectively with the $(v' \cdot r)v$ term it must accelerate the charge at the same rate as the reciprocal forces on the other charge accelerate that. In this way we can deduce that it has the value $-(m'/m)(v \cdot r)v'$, where m and m' are the masses of the charges moving at velocities v and v', respectively. This term cancels to zero when averaged for actions involving a circuital form of v, which explains why it has eluded detection. It can, however, reveal itself in a mammoth way as an anomalous force along the current discharge if m' is the mass of a heavy molecular ion and the action is part of the same circuit with electrons of mass m being the sole charge carriers in other parts.

This is verified by experiments such as those of Graneau and Graneau, recently reported (3), and this mass-dependent interpretation has been discussed in detail elsewhere (14).

In conclusion, it is hoped that the new approach to reconciling the electrodynamic and gravitational interaction by retarded energy transfer and action-at-a-distance, rather than simply retarded electric potential, will further research into the causal interpretation of relativistic field phenomena, with more attention being given to the quantum-electrodynamic features of the field theory involved.

Appendix. – It is quite usual for planetary motion to regard h, the angular momentum of unit planetary mass, as constant. Thus, in general relativity, when an equation of planetary motion is first derived in an appropriate four-dimensional space-time metric and then translated into a three-dimensional Euclidean form, h is taken to be constant throughout. The resulting equation is

$$(\mathrm{d}u/\mathrm{d}\varphi)^2 + u^2 = (GM/h^2)(e^2 - 1) + 2GMu/h^2 + 2GMu^3/c^2 , \tag{13}$$

where e is the eccentricity of the orbit.

Conversion of (13) to the form given by (11) and the onward solution depend upon h being constant through second-order terms in $(u/c)^2$. Differentiation of (13) with respect to φ and division throughout by $2(\mathrm{d}u/\mathrm{d}\varphi)$ gives equation (11). If h were not deemed to be constant, owing to mass variation in orbit governed by the usual relativistic formula, then the perihelion advance indicated by general relativity would differ substantially from that otherwise predicted. It appears, therefore, that the last term in (13) has already accounted for the full relativistic action and that constant h is assured also for planetary motion defined in the three-dimensional space metric.

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(14) H. Aspden: *Phys. Lett.*, in press.