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Einstein's Relativity and Quantum Physics

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There are reasons to reject the idea that a field in empty space is a real physical entity. The nonexistence of the electromagnetic field and the gravitational field as physical entities leads to far-reaching consequences. The basic equations sufficient to construct *classical electrodynamics* (the Maxwell equations and the Lorentz force equation) are obtained by combining quantum considerations with two premises: (a) there exists a subatomic particle, the *emon*, each concrete emon having a specific electric property described by a *spacelike* four-vector; (b) every concrete charged particle possesses a specific electric property described by a *timelike* four-vector. Some other points of interest are also discussed, in particular, ones related to Einstein's gravitational field as well as the "action-at-a-distance" versus "local-action" issue. Einstein's second postulate of special relativity is also shown to need some revision of principle.

1. INTRODUCTION

To make the exposition clearer, I first recall the following essential points (Mayants, 1984, 1994a,b).

(a) The experimental and theoretical parts of a science refer to entirely different subjects. The former deals with really existing objects called *concrete objects*. The latter is related to *abstract objects*, which do not exist in reality and are used merely in our considerations and discussions.

This point is extremely important, for a confusion of concrete and abstract objects leads to misunderstandings, misinterpretation of experimental results, and paradoxes. A good example of such a misinterpretation is Dirac's incorrect statement that a photon interferes with itself.

(b) The experimental part of a science is supposed to verify the findings of its theoretical part. But in sciences of different types the way of doing this is different. In a *probability-unrelated* (*deterministic*) science, the theoretical results related to an abstract object can be verified on each and every corres-

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ponding concrete object. In a *probability-related* science (quantum physics included) the theoretical probabilistic conclusions related to an abstract object need for their verification a gathering of experimental statistical data obtained by testing (at random) a large number of pertinent concrete objects.

This is a very important point as well, for a confusion of these two types of science leads to misunderstandings, a good example of which is the attempts to discuss EPR arguments by making use of experiments involving the spin of a particle or the photon polarization.

(c) Every concrete object has a set of properties, and every property has a set of values. Different concrete objects differ in at least one value of their properties.

Thus, properties belong to concrete objects—there are no concrete objects without properties, and there are no properties without concrete objects. This means that no property in itself (i.e., one that does not belong to a concrete object) exists in reality. This fact entails far-reaching consequences. Its immediate corollary is that empty space (i.e., the space outside any concrete objects) does not have any properties, including *coordinates* and *time*.

Therefore, no physical fields in empty space, in particular neither the *electromagnetic field* nor the *gravitational field*, exist in reality—these fields are solely mathematical ones.

The nonexistence of the free electromagnetic field as a physical entity requires reconsideration of related matters.

It will be shown, in particular, that the basic equations sufficient to construct *classical electrodynamics* (the Maxwell equations and the Lorentz force equation) can be obtained by combining quantum considerations with two premises: (a) there exists a subatomic particle, the *emon*, each concrete emon having a specific electric property described by a *spacelike* four-vector; (b) every concrete charged particle has a specific electric property described by a *timelike* four-vector.

Einstein's theory of gravitation and some other aspects of the topic under consideration will also be discussed.

2. EINSTEIN'S SECOND POSTULATE (ESP)

This postulate of Einstein's special relativity theory states that the speed of light [rather, of any electromagnetic wave (EMW)] in empty space is one and the same constant in any inertial coordinate system (ICS). It has turned out that this constant, denoted conventionally by c, should be the ultimate velocity of motion of any physical object.

The experimental verification of ESP is impossible in principle, for the measurement of the speed of light (EMW) can never be made to an absolute accuracy (as is certainly the case for any measurement). The most accurate (indirect) measurements of that speed have been made to an accuracy of a few decimeters per second (Bates, 1988). Although these inaccuracies are very small in comparison with c, which is fixed currently (Bates, 1988) to be 299,792,458 m/sec, they differ nonetheless from zero and can well conceal the possible differences between the velocities of EMWs and c. The following reasoning, which also corroborates the above assertion of nonexistence of the free electromagnetic field as a physical entity, shows that those differences really exist, which makes it necessary to revise the wording of ESP.

In terms of photons, ESP states that every *concrete* photon, regardless of its energy, must move exactly at rate c, which means that its rest mass must be precisely zero. Every concrete free particle, including a photon, possesses in every ICS the energy E and hence the mass

$$m = E/c^2 \tag{1}$$

It also possesses the momentum

$$\mathbf{p} = m\mathbf{v} \tag{2}$$

where $\mathbf{v}$ is its vector velocity in that ICS. The equation

$$E^2 = c^2p^2 + (m_0c^2)^2 \tag{3}$$

is also valid for any concrete free particle, including a photon, in every ICS, where m_0 is its rest mass.

The "wave" properties of photons, as well as their "wave–corpuscle" connections, do not differ from those of any regular particle either, and the pertinent equations are valid for all the particles, regardless of their rest mass. This is also true for the wave equation

$$\nabla^2\psi = (1/v_p)^2\ \partial^2\psi/\partial t^2 \tag{4}$$

which is a modified Schrödinger equation for a free particle, where ψ is the wave function describing the stationary state of the free particle and $v_p = E/p$ is the pertinent wave velocity.

Hence, the supposition that the rest mass of a particle may be zero is consistent with all the valid equations it obeys. But can such a concrete particle exist in reality? This question has already been answered in the negative (Mayants, 1981, 1984, 1989a). Here I offer a new proof of this contention.

Let us consider a purely mathematical equation

$$xy = \epsilon^2 \tag{5}$$

where ϵ is a nonnegative number.

When $x = \epsilon > 0$, $y = \epsilon$ is valid. Since this is true for any $\epsilon > 0$, no matter how small it is, the same should hold for $\epsilon = 0$ as well. To be sure, a general solution to the equation $xy = 0$ for $x = 0$ is $|y| \geq 0$, but by continuity we should choose just $y = 0$ as a proper particular one.

Now, from (1)–(3) it follows that

$$\eta m = m_0 \tag{6}$$

where

$$\eta = (1 - \beta^2)^{1/2} \tag{7}$$

with $\beta = v/c$. We can make m and m_0 dimensionless by choosing appropriate units. Since (6) is of the same form as (5), we come to the conclusion that for $m_0 = 0$ and $\eta = 0$, $m = 0$ would hold as well. However, (6) is valid in any ICS. Therefore, if the rest mass of a concrete particle were zero, then its mass and hence its energy and momentum would have to be zero as well in any ICS, which is equivalent to the nonexistence of such a particle. Thus, no concrete particle, including a concrete photon, can have zero rest mass.

Since the rest mass of a concrete photon must be nonzero, it cannot move exactly at c in any ICS, which means that the corresponding EMW cannot propagate in empty space exactly at c either. This completes the proof that the velocity of EMWs in empty space cannot be precisely c, and ESP should be property corrected. On the other hand, the differences between the EMW velocities and c are so small that they cannot be revealed by direct measurements at least for now. Therefore, the corrected ESP can be put as follows: The speed of light (EMWs) in empty space is enormously close to the ultimate rate c in any ICS.

This correction changes nothing in many applications of ESP, but it is one of principle and should be taken into account where necessary.

3. THE EMON

The fact that the rest mass of a concrete photon is nonzero implies that, instead of nonenumerable set of concrete photons of different energies, there exists a subatomic electromagnetic particle of extremely small rest mass (Mayants, 1981, 1984, 1989a,b). Since this particle can even be at rest, it should no longer be called a "photon," the more so because at nonrelativistic rates it has only the electric property (1989c) and cannot, hence, produce the free electromagnetic field characteristic of photons. I have named this particle the emon. The motion of concrete emons at a variety of rates of nearly c determines the whole set of concrete photons. Thus, it is just a concrete emon moving at a velocity near c which is usually called a photon. The emon has obviously the same spin 1 as the photon has. This means that the emon is a compound particle, which is in line with the fact that at high enough energy (over 10^6 eV) it decays into an electron–positron pair.

Now a few words about the possibility to find the emon rest mass experimentally. Denoting it by m_{em}, we get from (6), in view of (1) and $\nu = E/h$,

$$\eta\nu = \nu_{em} \tag{8}$$

where $\nu_{em} = m_{em}c^2/h = 1.36 \times 10^{47} m_{em}$ sec^{-1}. It follows from (8) that a lower limit ν_0 of radio wave frequencies should exist, satisfying the inequality

$$\nu_0 > \nu_{em} \tag{9}$$

If it is possible to find ν_0 experimentally, then one can estimate the upper limit of m_{em} as

$$m_{em} < h\nu_0/c^2 = 0.74 \times 10^{-47}\nu_0 \text{ g} \tag{10}$$

Another possibility in principle to find m_{em} and c arises from the dependence of the EMW velocities on them. In view of (7), (8), and the fact that $1 - \beta << 1$ for all EMW,

$$(\nu_{em})^2 = 2\nu^2(1 - \beta) \tag{11}$$

Hence,

$$1 - \beta \cong (\nu_{em})^2/2\nu^2 \tag{12}$$

Even if the lower limit frequency is $\nu_0 = 10^3$ sec^{-1}, which is apparently very much overstated, the estimate of $1 - \beta$ for visible light ($\nu \sim 10^{15}$ sec^{-1}), in view of (9), would be $1 - \beta < 10^{-24}$, while the aforementioned accuracy of light velocity measurement (Bates, 1988) is about 10^{-9}. Thus, the recently accepted fixed value of c given above (Bates, 1988) can be regarded as correct to a relative accuracy of 10^{-9}. Now that c is known to a great accuracy, (11) is an equation in the unknown ν_{em}. If the velocity of some very long wave is measured to a sufficient accuracy, this would allow one to estimate ν_{em}. The future will show whether or not such a measurement is feasible.

The examination of another possible way of finding ν_{em} by measuring the difference in the times of arrival of two waves emitted simultaneously by an extraterrestrial source shows that it is also unrealizable (at least for now).

It is essential, however, that no matter whether or not we know the emon rest mass, it is definitely nonzero, and this makes a difference.

4. THE ELECTROMAGNETIC FIELD QUANTUM CONNECTION

The conventional belief that the free electromagnetic field is the primary entity, the photons being its outcome, should be reversed. It is just the photon (more accurately, the emon) which should be considered the primary entity, the free electromagnetic field being its outcome. More exactly, the latter refers to an abstract photon and is revealed as a result of the presence of an enormous number of concrete photons (i.e., relativistic emons).

Since the free electromagnetic field obeys the pertinent Maxwell equations, such a point of view puts forward the task of getting them from the emon-founded considerations. This has successfully been accomplished in the following way (Mayants, 1989c).

The world point representing a concrete emon is described by a 4-vector $x^j = (x^0, \mathbf{r})$, where $x^0 = ct$, and $\mathbf{r}$ is the radius vector whose components are the rectangular coordinates x, y, and z.

The mechanical properties of a concrete emon are represented (in any ICS) by the 4-momentum $p^j = (p^0, \mathbf{p})$, where $p^0 = m_{\text{em}}c/\eta$, $\mathbf{p} = m_{\text{em}}\mathbf{v}/\eta$, and η is given by (7). It is convenient to use, instead, the wave 4-vector $k^j = p^j/h$. The tensor formed of k_j and x^l is $k_j x^l$; its contraction is the 4-scalar

$$k_j x^j = Inv \tag{13}$$

The specific electric property of a concrete emon is found to be represented in a rest system by a spacelike 4-vector $a^j = (0, \mathbf{a})$, where $\mathbf{a} = (a_x, a_y, a_z)$ has only one nonzero component $a_y = a_{(0)}$. The contraction of the tensor $a^j k_l$ is

$$a^l k_l = -\mathbf{ak} = 0 \tag{14}$$

which means that the electric vector a is perpendicular to the direction of the concrete emon motion.

The antisymmetric tensor

$$f_{jl} = a_j k_l - a_l k_j \qquad (j, l = 0, 1, 2, 3) \tag{15}$$

has six essentially different components. The three components $f_{0l} \equiv d_l$ ($l = 1, 2, 3$) form the polar electric vector $d = k_0\mathbf{a}$ of a concrete emon, while the three components $f_{12} \equiv -b_z, f_{13} \equiv b_y$, and $f_{23} \equiv -b_x$ present its axial magnetic vector $\mathbf{b} = \mathbf{k} \times \mathbf{a}$, which is obviously perpendicular to both the electric vector and the direction of the emon motion. In a rest system, $\mathbf{d}$ has only one nonzero component: $d_y = d_{(0)} = m_{\text{em}}ca_{(0)}/h$, while all the components of $\mathbf{b}$ are zeros. This means that in a rest system a concrete emon has only the electric property (determining, by the way, the photon polarization)—it acquires the magnetic property of (practically) the magnitude of the electric vector only when moving at relativistic rates, i.e., when it becomes a photon.

There is one more tensor of interest, $f_{jml} = f_{jm}k_l$, which has 24 essentially different components that obey eight equations. The above vectors and tensors are all properties of a concrete free emon.

When turning to an abstract free emon, we come first to a wave function describing its state, which is the solution to both the pertinent Schrödinger equation and the related second-order differential wave equation (4). This function is proportional to $\Phi = \exp(-ik_jx^j)$ which is, in view of (13), a relativistic invariant. The values of k^j common for all the concrete emons of one set determine the state of the corresponding abstract free emon. The probability that this abstract emon has four coordinates in the vicinity of the world point described by x^j—i.e., the probability that some free emon happens to be in that vicinity—is determined by Φ. This means that since a concrete emon carries all its properties, the probability that the abstract emon has the corresponding values of those properties in the vicinity of the world point x^j is also determined by Φ. The statistical distribution of the properties, which results from a proper statistical experiment, is thus also determined by Φ.

The function Φ, from the mathematical standpoint, is a field. Multiplication of the quantities which represent the vector and tensor properties of a concrete emon by Φ (or $-i\Phi$) yields particular mathematical fields (Mayants, 1989) which prove useful in calculation. It is precisely these fields which are regarded in classical electrodynamics as the vector and tensor physical quantities related to one *electromagnetic field*. The 4-vector

$$A^j = (A_0, \mathbf{A}) = a^j\Phi \tag{16}$$

is the 4-potential of this field. The tensor

$$F_{jl} = \partial A_j/\partial x_l - \partial A_l/\partial x_j \tag{17}$$

is the electromagnetic field tensor. Equation (17) yields

$$\mathbf{E} = -i\mathbf{d}\Phi = (-1/c)\,\partial\mathbf{A}/\partial t; \qquad \mathbf{H} = -i\mathbf{b}\Phi = \nabla \times \mathbf{A} \tag{18}$$

The components of the tensor

$$F_{jkl} = -f_{jkl}\Phi = \partial F_{jk}/\partial x^l \tag{19}$$

obey eight equations which can be written as

$$\left.\begin{aligned} \nabla \times \mathbf{E} &= -(1/c)\,\partial\mathbf{H}/\partial t \\ \nabla\cdot\mathbf{H} &= 0 \end{aligned}\right\} \tag{20}$$

and

$$\left.\begin{aligned}\nabla \times \mathbf{H} &= \beta^2(1/c)\ \partial\mathbf{E}/\partial t\\ \nabla\cdot\mathbf{E} &= 0\end{aligned}\right\} \tag{21}$$

where β is the relative velocity of the emon (see Section 2).

Equations (20) represent the respective pair of Maxwell equations. Equations (21) represent the second pair of Maxwell equations if $\beta = 1$ only. But $\beta = 1$ is satisfied to an enormous accuracy for any EMW known, as was shown in Section 2. Hence, (21) are also valid Maxwell equations when (corrected) ESP is valid, i.e., for any EMW.

Incidentally, the above considerations show that the theory of the electromagnetic field is the theoretical part of a probability-related science. We shall recall this later.

By expressing the energy density of the free electromagnetic field in both electromagnetic and mechanical terms, we get the connection between the electric property $d_{(0)}$ and the rest mass m_{em} of the emon, namely,

$$d_{(0)} = (8\pi m_{\text{em}})^{1/2}c \tag{22}$$

Since $\mathbf{E}$ is proportional to $d_{(0)}$ and $|\mathbf{H}| = \beta|\mathbf{E}|$, as can be shown, no electromagnetic field would exist at all if m_{em} were zero.

The case of the charge-related electromagnetic field requires a somewhat different treatment. The specific electric property of a concrete particle of charge e is to be represented in a rest system by a *timelike* four-vector $e^j = (e, 0)$. For reasons explained elsewhere (Mayants, 1989), one should immediately turn to the corresponding abstract free particle and form a pertinent field for it (in the rest system) by multiplying e^j by the magnitude of the function describing its state. This yields the four-potential (in the rest system)

$$A^j = e^j/r = (\varphi, \mathbf{A}) \tag{23}$$

where $\varphi = e/r$ and $\mathbf{A} = 0$.

That is enough to get all the other quantities and equations related to an abstract free charged particle. We have, in particular,

$$(1/c)\ \partial\varphi/\partial t + \nabla\cdot\mathbf{A} = 0 \tag{24}$$

in any ICS, which is the well-known Lorentz condition. The electromagnetic field tensor is defined by the same equation (17) as in the preceding case. This time, however, since $A^0 = \varphi$ is nonzero, we have, instead of (18),

$$\mathbf{E} = -(1/c)\ \partial\mathbf{A}/\partial t - \nabla\varphi; \qquad \mathbf{H} = \nabla \times \mathbf{A} \tag{25}$$

The same equation (20) which follows immediately from (17) and (19) represents the first pair of Maxwell equations for this case, too (Mayants, 1989).

The contraction of the tensor $\partial F^{mk}/\partial x_l \equiv F_l^{mk}$ is

$$F_k^{mk} = (4\pi/c)j^m \tag{26}$$

where

$$j^m = (c\rho, j) \tag{27}$$

is the *current 4-vector*, $\rho = \rho^{(R)}/\eta$ is the *charge density*, $\rho^{(R)} = e\delta(r)$, and $\mathbf{j} = \rho\mathbf{v}$ is the *current density vector*. Equation (26) can be rewritten as

$$\left.\begin{aligned} \nabla \times \mathbf{H} &= (1/c)\ \partial \mathbf{E}/\partial t + (4\pi/c)\mathbf{j} \\ \nabla \cdot \mathbf{E} &= 4\pi\rho \end{aligned}\right\} \tag{28}$$

which is the second pair of Maxwell equations. Equations (28) coincide formally with (21) (for $\beta = 1$, which is the case for any EMW known) when $\rho = 0$.

Since the total free electromagnetic field $F_{(\mathrm{em})kl}$ for any number of abstract emons and the total charge-related electromagnetic field $F_{(\mathrm{ch})kl}$ for any number of abstract free charged particles obey the same equations, so does their sum: $F_{kl} = F_{(\mathrm{em})kl} + F_{(\mathrm{ch})kl}$.

Consider now the contraction $F_{kl}j^l \equiv s_k$ of the tensor $F_{kl}j^m$, where j^m is the total current 4-vector. In view of (27), the spatial part of the contravariant four-vector s^k is

$$\mathbf{s}_L = \rho(\mathbf{E} + (1/c)[\mathbf{v} \times \mathbf{H}]) \tag{29}$$

which is the well-known *Lorentz force density* (Becker, 1933) determining the dynamical laws of the electromagnetic field.

The set of equations (20), (28), and (29) is sufficient to construct classical electrodynamics, as has been shown elsewhere (Becker, 1933).

5. ON EINSTEIN'S THEORY OF GRAVITATION

In search of general relativity, Einstein found the explanation of the phenomenon of gravitation. The equation he obtained has been confirmed, first of all, by the fact that in the first approximation it yields widely experimentally verified Newton's law of gravitation. Further confirmation of the correctness of Einstein's equation has been given by the quantitative experimental verification of the three subtle effects predicted by the equation, which could not find their explanation in Newton's approximation. Thus, Einstein's equation of gravitation should be recognized as a correct one (at least for now). This equation connects in the final analysis the metric tensor of the space-time continuum which determines its geometrical structure to the distribution and motion of concrete massive bodies. In their presence, the metric tensor slightly differs from the simplest one valid when there are no massive bodies nearby. Because of the slight alteration of the metric tensor the 4-space becomes curved, and its geodesic lines become slightly different from the ones in a noncurved space, which are straight lines.

A concrete body moves, in absence of any physical forces, along some geodesic line. When there are no massive bodies, they are all straight lines, and the motion of the body is straight-line uniform. In the presence of concrete massive bodies, the geodesic lines are curved, and hence concrete bodies move along them with acceleration, even though no physical forces are acting on them. Thus, the acceleration is due, it should be stressed again, solely to the space-time curvature—not to some other reason.

It should also be emphasized that Einstein's equation of gravitation belongs to the theoretical part of a probability-unrelated science, since the results following from the equation are applicable to each and every concrete system. Therefore, the theory of gravitation has nothing to do with probability and, hence, with quantum physics either.

Now a few words about Einstein's interpretation of gravitation. His adherence to the idea of real existence of fields in empty space made him introduce the gravitational field as a physical entity, which seems inadequate to me for the reasons I explained before. There is no gravitational field, no gravitational waves, no gravitational energy, etc. Empty space has no physical fields whatsoever, I repeat it again.

6. CONCLUDING REMARKS

The problem of the real existence of fields is supposed to be related in a way to a widely discussed, particularly in connection with the attempts to check Bell's inequalities experimentally, issue of "action at a distance" versus "local action." However, this issue can easily be settled without any reference to the notion of "field." Indeed, any action should be meant as taking place in reality, i.e., as a concrete action. Therefore, it should be an immediate contact action of one concrete object on another concrete object, i.e., a local action.

In the case of the electromagnetic field, which is a mathematical field of quantum origin, it is just concrete emons (and perhaps some other concrete particles of extremely small rest mass) moving at rates very close to c which are responsible for such an action. In the case of the gravitational field, there is no direct interaction between two distant massive bodies whatsoever. A change in the distribution and motion of concrete massive bodies yields the corresponding change in the space-time geometry which alters the acceleration of some other massive body. However, it is not a "far action," neither is it a "local action." Again, it is not a direct influence of one concrete body on another distant one, and it has nothing to do with the ultimate rate c, which is related solely to *physical signals* carrying energy and hence mass, whereas the change in the space-time geometry is not of this kind.

I would like finally to say this. In my view, the theories of the electromagnetic and gravitational fields cannot be united because, to say nothing of the nonexistence of these fields as physical entities, they deal with sciences of different types—the former belongs to a probability-related science, whereas the latter belongs to a probability-unrelated science.

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