BOOK REVIEW

The Enigmatic Photon: Volume 1: *The Field $B^{(3)}$*, by Myron Evans and Jean-Pierre Vigier, x+217pp.; Kluwer Academic Publishers, 1994 ISBN 0-7923-3049-8 (hard cover); Volume 2: *Non-Abelian Electrodynamics*, by Myron Evans and Jean-Pierre Vigier , x+171 pp., Kluwer Academic Publishers,1995 ISBN 0-7923-3288-1 (hard cover); Volume 3: *Theory and Practice of $B^{(3)}$ Field*, by Myron W. Evans, Jean-Pierre Vigier, Sisir Roy and Stanley Jeffers, x+228 pp., Kluwer Academic Publishers, 1996 ISBN 0-7923-4044-2(hard cover).

The Enigmatic Photon constitutes a declaration by prolific authors in favour of the existence of a real field, called $\mathbf{B}^{(3)}$, which plays a very central role in the context of modern physical theories. This is a very good reason to consider it an important book which must be read. If we believe that the method of science consists of conjectures and refutations, all the implications pointed out by the authors should be seriously considered, both, theoretically and experimentally.

The Enigmatic Photon is a book written in order to present a systematic development of $\mathbf{B}^{(3)}$, claimed by the authors as the fundamental magnetizing field of electromagnetic radiation. It was written in three volumes which explore many aspects of the problem, such as the experimental situation, mathematical consequences and possible applications.

According to Evans and Vigier (preface/Volume 1), the anti-symmetric part of the intensity tensor of light is directly proportional in free space to an entirely novel phase free, magnetic field of light, which was identified as $\mathbf{B}^{(3)}$... .The definition of $\mathbf{B}^{(3)}$ comes from the cyclically symmetric relations between fields (eqs.(4), Volume 1) where, the fields $\mathbf{B}^{(1)}$, $\mathbf{B}^{(2)}$ and $\mathbf{B}^{(3)}$ are simply components of the magnetic flux density of free space electromagnetism in a circular, rather than in a Cartesian basis .

In fact, the theory of $\mathbf{B}^{(3)}$ field is very impressive, but a critical and sound evaluation requires extensive studies, including, of course, experimental tests. One positive point is a rich web of concepts and phenomena related to $\mathbf{B}^{(3)}$: theory of finite photon mass, theory of optically induced line shifts in NMR, inverse Faraday effect, the optical equivalent of the Aharonov-Bohm effect, the d Alembert equation, the Proca equation and many others.

Throughout the book, the authors emphasize the relevance of the relationship between the $\mathbf{B}^{(3)}$ field and the finite photon mass concept. The d Alembert equation is compatible with a infinite range of interactions, unlike the Proca equation, which is compatible with a field implying a finite range. The infinite range of the electromagnetic interaction implies a photon mass equal to zero, whereas a finite range implies a photon mass different from zero. These ideas were advanced by several authors in different contexts. For example, Yukawa in his theory of mesons arrived at the conclusion following which the range of nuclear interaction and the meson mass are inherently connected concepts. Other examples are de Broglie in 1934 and Goldhaber and Nieto in 1971. According to Evans and Vigier the photon mass is evaluated in the range 10^{68} to 10^{45} kg. This implies measurable effects on an astronomical scale, for example the tired light phenomena . By contrast with special relativity, photons with mass cannot travel with the speed *c* in free space.

Systematic research into the $\mathbf{B}^{(3)}$ field enables an articulated study of the meaning of many important equations of physics: including d Alembert, Proca, Yukawa, Klein-Gordon, Duffin, Kemmer and Petiau, de Broglie (1934), *etc*.

In Chapter 3/Volume 1 the authors develop an argument in favour of the Einstein-de Broglie concept of duality in connection with $\mathbf{B}^{(3)}$ field. $\mathbf{B}^{(3)}$ is regarded as a stationary state of the electromagnetic field *in vacuo*. Some recent experiments supporting the coexistence of wave and particle properties of light are emphasized. One relevant example is an experiment using a beam splitter composed of two prisms separated by a gap.

In Chapter 7/Volume 3, $\mathbf{B}^{(3)}$ is interpreted as a pilot field. In this context, $\mathbf{B}^{(3)}$ is regarded as the pilot field of the angular momentum of the photon.

Throughout the book, possible experimental evidence for the existence of $\mathbf{B}^{(3)}$ field is considered. According to the authors (Ch.9/Vol. 3) a revised version of the experiment of Deschamps *et al.* can provide evidence of $\mathbf{B}^{(3)}$ through the expected square root intensity profile of inverse Faraday induction.

In Volume 2, Non-Abelian electrodynamics is developed. The connections of the $\mathbf{B}^{(3)}$ with Dirac equation, the Higgs phenomenon, unified field theory and quantum electrodynamics are considered.

It is argued that $\mathbf{B}^{(3)}$ itself is of fundamental significance. For example, with formula (472) of Vol. 3 the authors are able to express the photon mass directly in terms of the $\mathbf{B}^{(3)}$ field.

Cosmological implications of the $\mathbf{B}^{(3)}$ field are also taken into consideration. The authors argue that $\mathbf{B}^{(3)}$ should be considered the primordial relict magnetic field in relativistic cosmology. The authors consider that the $\mathbf{B}^{(3)}$ field can be examined in the microwave background radiation (MBR). They hope that the COBRA/SAMBA project of the European Space Mission will be able to measure the $\mathbf{B}^{(3)}$ field through the ratio of longitudinal and transverse components of the MBR.

Since the inference of $\mathbf{B}^{(3)}$ in Dec. 1991 at Cornell, many papers have been written on the subject. The following journals have published papers on the $\mathbf{B}^{(3)}$ theme: *Physica A* and *B* , *Physical Review A, D* and *E*, *Journal of Physics*, *Foundations of Physics*, *Foundations of Physics Letters*, *Il Nuovo Cimento A*, *B* and *D*, *Advances in Chemical Physics*, *Journal of Molecular Liquids*, *Journal of Molecular Structure*, *International Journal of Theoretical Physics*, *Modern Physics Letters*, *Physica Scripta*, *Speculations in Science and Technology*, *Apeiron*, *Review of Mexican Physics* and *Hadronic Journal*.

In spite of the three volumes of *The Enigmatic Photon* and a relatively good response in the scientific literature, the authors must contend with opponents of their ideas in order to obtain acceptance of the $\mathbf{B}^{(3)}$ theory in the scientific community.

Among the electronic messages delivered by Evans we can find one in which he writes: If Nature actually tell us in the end analysis that $\mathbf{B}^{(3)}$ is zero, no one would be better pleased than I, because we have learned a lot. However, I feel that it is non-zero. Censorship of my ideas is not scientific, and this is my major point of argument. This expressive text leads us to the important topic of how theories are accepted within the scientific community. Of course, the inherent merits of a given theory are not sufficient to guarantee its victory in competition with other rival theories. According to Thomas Kuhn, Paul Feyerabend and many others, non-scientific censorship of relevant ideas should not surprise us. Indeed, the scientific enterprise is not entirely scientific . However, the best methodology consists of critical and rational analysis of tradition, and so dogmatic attitudes must be rejected.

Despite the fact that the terms existence and real physical fields give rise to complex scientific and epistemological debate, it is possible to understand the concept of real physical field in a relatively simple and pedestrian way. For example, according to Maxwellian electromagnetism, the electric and magnetic fields are both considered real fields; the vector potential, on the other hand, would constitute, merely, a mathematical artifact in order to perform useful calculations. As is well known, this concept of reality was radically changed by the Aharonov-Bohm effect, which shows that for regions for which the electric and magnetic field are both equal to zero, the vector potential works, and so constitutes a real physical entity.

We can find the following happy new year electronic message delivered by Philipp Ignatovich : [To $\mathbf{B}^{(3)}$ or not to $\mathbf{B}^{(3)}$, that is the question... W. Shakespeare, *Journal of Literature*, 16th century (first recorded reference: (3) left out due to printer s error)]. Hamlet s drama consisting of the necessity of a decision between two radically different and mutually exclusive attitudes can also be interpreted in the ontological sense *i.e.,* to be or not to be in the sense of the existence (or not) of the $\mathbf{B}^{(3)}$ field.

My impression is that the richness of the concepts involved and the related phenomena, as well as the articulated web of arguments presented in the book *The Enigmatic Photon* strongly recommends extensive and deep study.

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Why Do Clock Rates Lack Group Properties?

The problem of the relationship of group theory to physics and of clock rates to group theory is inconclusively explored. An illustration of the problem is the failure of clock rates in special relativity theory to exhibit group properties.

1. Introduction

The impression is widespread among theoretical physicists that group properties lie at the heart of physical description. This view has evolved to the point where one could almost say that a necessary condition for a physical attribute to possess reality is that it exhibit group properties. Thus, when the shocking discovery was made that the Lorentz transformations descriptive of uniform, non-rotary motion in more than one spatial dimension lacked group properties, this was viewed as a crisis of such magnitude as to warrant redefinition of *the physical attribute of* ***inertiality*** to permit the coordinate system rotations necessary to restore mathematical group properties. (Thus was born the Thomas precession, the higher-order nonreciprocity of velocities[1], *etc*.)

The trouble is that nature is extremely various in its aspects, so that the choice of aspect to be accorded group properties is an identification of such subtlety and profundity as to hold no recognized place among the arts nor, to be sure, among the sciences. The subject is beset with pitfalls. For instance H. Takeno thought that angular velocity ought to have group properties; so, applying this thought and using special relativity theory (SRT), he rashly made a prediction[2] about a consequence of the Thomas precession that proved to be directly contrary to observation[3].

Thus it is hazardous to seize upon a perceived aspect of nature, assign it group properties, and expect nature to conform to the resulting predictions. Such a strategy may succeed or it may not. Physicists seem to possess few insights to guide their expectations in the matter. (That is why it is foolhardy to assume success, as has been done in the case of group properties of the Lorentz transformation, without explicit experimental validation.) In the present paper I shall not attempt to improve this situation but shall merely emphasize its seriousness by exhibiting another failure of the groupy approach to physical description. Here the aspect of nature examined will be *clock rates*.

Seemingly clock rates ought to be a reliable aspect of physical reality. Within pure kinematics (*i.e*., with neglect of gravity) there is every reason to believe and we shall assume here that clock rate is a *state function*. That is, kinematic clock rate depends uniquely and only on clock state of motion, not on history of acceleration, *etc*. Thus all (idealized) clocks in a given state of motion run at the same rate regardless of how they may have happened to enter that state. (This is not at all the same thing as saying that the *readings* of co-moving clocks must agree. On the contrary, clock phase or reading is generally accepted as path-dependent, owing to inexactness of the individual clock s proper-time differential $d\tau$.)

Thus if it were safe to identify an apparently real aspect of nature and automatically assign it group properties if that were the key to doing theoretical physics there could hardly be a more appealing candidate than clock rates upon which to exercise this approach. So, let us try it, using the kinematics of SRT.

2. Analysis

Consider collinear motion of three inertial systems. The rate of clocks at rest in system 1 is, let us say, $R[1] = r_0$. The rate of those at rest in system 2 is $R[2] = r_0\sqrt{1-a^2}$, where $a = v_{21}/c$, v_{21} being the velocity of system 2 as measured by instruments at rest in system 1, and c is light velocity. The rate of clocks at rest in system 3 is the rate of clocks at rest in 2 multiplied by $\sqrt{1-b^2}$, where $b = v_{32}/c$ and v_{32} is the velocity of system 3 as measured by instruments at rest in 2. Thus the rate just mentioned is $R[3] = r_0\sqrt{1-a^2}\sqrt{1-b^2}$. This last can alternatively be expressed as $R[3] = r_0\sqrt{1-d^2}$, where $d = v_{31}/c$ and v_{31} is velocity of system 3 as measured by instruments at rest in 1. By the Einstein velocity composition law we have

$$d = \frac{a+b}{1+ab} \ . \qquad (1)$$

Hence on equating the two expressions for $R[3]$ and squaring we obtain

$$\left(1-a^2\right)\left(1-b^2\right) = 1-d^2 = 1-\left(\frac{a+b}{1+ab}\right)^2 . \qquad (2)$$

This should be true as a mathematical identity. But in fact it is manifestly false unless *a* or ***B*** vanishes. So, the requirement of group properties of clock rates fails within SRT.

There is nothing to be done about this. It cannot be fixed even by departing from SRT and patching up the velocity composition law. Thus for the first equality in (2) to hold it would be necessary that *d* satisfy

$$d = \sqrt{a^2(1-b^2)+b^2} \ , \qquad (3)$$

which is manifestly nonphysical, since for $a \ll 1$ and $b \ll 1$ it yields $d \approx \sqrt{a^2 + b^2}$, instead of the proper Newtonian limit $d \approx a + b$. In fact, it would seem that there is no kinematics that both asserts time dilatation and accords group properties to clock rates.

We conclude that group theory is a blunderbuss that makes a great noise and is perfect for dazzling graduate students; but the physicist bold enough to try to use it to hit a target is just as apt to blow his foot off.

3. Implications

Clock rate appears undeniably to be an aspect of physical reality (for one would surely expect any physical state function to have a counterpart out there). Its failure to possess group properties vis-à-vis inertial motions is surprising. What, if any, might be the implications of this failure for physical description?

It does not necessarily provide grounds for rejecting SRT. Other things may do that, but not this, for the reason that most alternative theories of physical pedigree seem to do no better. Exceptions are absolute space and time theories such as that of Wesley[4], in which time dilatation does not occur, so that clock rates are the same in all inertial systems. (They transform identically and thus have [degenerate] group properties.) Such theories have their own drawbacks, however, in that throughout the range of physical experience one keeps encountering observed *apparent* time dilatations (*cf.* the spinning Mössbauer experiments, GPS observations, *etc.*), each of which needs its own special explanation in terms of statistical effects or whatever, once one has ruled out any universal effect of motion on timekeeping. It seems almost easier to accept appearances.

Setting aside the absolute space-time theories, then, how is kinematics to be conceived or reconceived to fit with this apparent failure of timekeeping groupiness? One can only speculate: Perhaps the problem with clock rates is rather special to such rates and does not signal a general breakdown of the groupiness ideology in physics. In this case one might suppose that indeed clock rates are in some sense not real until they become *knowable* and they do not become knowable until *operational procedures* have been specified for clock calibration. Metric standard calibrations, both for space and time, are a much-neglected aspect of the physics supposedly associated with Einstein s kinematics. In SRT inertial systems are generally presumed to come from nature with axes and clocks pre-calibrated. Such systems are pictured as *eternally* moving and as having been calibrated in respect to an agreed physical meaning of the meter and second when? When, indeed? Before 1905? Before the Flood? And, whenever it was, how was it done? By accelerative transfer of standard clocks and meter sticks? No, *Gedank* again: Acceleration (at least of extended structures) is a no-no in SRT. Truth to tell, calibration never occurred. We overlooked it and could not that be the root of the problem? [*Historical note:* Einstein s 1905 paper solved the axis calibration problem by considering two inertial systems initially comoving, one being then set into motion with respect to the other by means and with worldline shape consequences (for the metric standard thus set into motion) entirely unspecified. This will not do, because of the logical *Verbot* on acceleration. Three generations of logic-choppers have been content to infer metric properties from the *equations* developed through ignoring axis calibration!]

In summary, if one tries to get the clock rates (time dilatations) of three of SRT s collinearly moving inertial systems to interrelate consistently, as the members of a group must do, one gets a mathematical contradiction. This lack of group properties may mean that clock rates are not real perhaps until calibration by accelerative transfer of a standard clock makes them so. But that cannot occur rigorously within SRT, which (in its unseemly haste to get to the mathematical equations) shuns acceleration and accelerative calibrations; so it is conceivable that some other kinematics may be required in order to cast more meaningful light on our title question. Such an alternative theory would have to begin with acceleration of metric standards, not bring calibration in as a neglected afterthought. Since it would thus be a kinematics founded on acceleration, there is no reason to imagine that it would greatly resemble SRT as a logical construct.

References

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Free Trade between Mass and Energy?

The validity of E = mc² for configurational energy is reinforced. Energy conservation is a global principle implying distant simultaneity. The presence of electromagnetic radiation and of long-range gravitational interaction does not allow a rigorous isolation of systems. The mass defect occurring in nuclear reactions is due to the interplay between binding (configurational) and kinetic energy of microparticles. The convertibility of different forms of energy relies on the universality of action, while the practical usefulness depends on a characteristic time.

1. Mass and Rest Mass

Strange as it may sound in AD 1997, the concepts of mass, energy, and their conservation law are far less understood than usually believed. To begin with, mass, *m*, is defined as the proportionality factor between velocity **v** and the first *dynamic* quantity called linear momentum: **p** = *m***v**. While *m* could well be a function of the *absolute* velocity **v** (that would be a kinetic mass), it is not clear whether a *rest mass* corresponding to **v** = 0 has physical meaning at all. From the point of view of of *external* dynamics -the motion of an object under the influence of external agents the rest mass of a point-like object is obviously meaningless, since all *internal* dynamics is *a priori* excluded. Only an extended object with internal structure, degrees of freedom, *and dynamics* could possess a rest mass as-viewed-from-outside . Viewed from inside, the rest mass of the object is the overall manifestation of internal kinetic masses! Special relativity theory (SRT), a kinematical theory devised for point-like, non-interacting particles moving freely in vacuum, is therefore fundamentally inadequate to tackle the problem in general and that of rest mass in particular. Unlike in special relativity, the concept of rest mass makes particle modelling compulsory!

In the early models concerning *m*(*v*), mass was thought of as being of *electromagnetic origin*. (Einstein himself thought of electromagnetic mass without, however, considering the inherent consequences such as the contribution of radiation to the total energy or the omnipresence of charges). Only the concept of electromagnetic mass would allow the velocity of light, *c*, to enter into mechanics and provide a basis for all experiments or deliberations on either the famous relationship $dE = c^2 dm$ or its equivalent $m(v) = m(0)\left(1 - v^2/c^2\right)^{-1/2}$ which are in line with physical dynamics. The electrodynamics to be chosen is therefore one important unknown feature involved in an experiment on the behaviour of masses as their absolute velocities approach that of light (Wesley 1991). The idea of inertia of energy in the heads of Weber, Poincaré, Hasenöhrl, and others came from electromagnetic radiation. The presence of *charges* in all experiments yielding evidence for $m(v)$ to this day is in the same line of attack to the problem. No matter what kind of evidence we try to rely upon to solve the mc^2 puzzle, we are always dealing with *charges and radiation*.

2. Energy and its Conservation

The only straightforward definition within the so-called kinetic energy theorem, has been that of *kinetic* energy of a point-like object, *i.e.* *vis viva* $0.5mv^2$. All other forms of energy are defined in order to comply with the energy conservation principle. In other words, energy is tautologically defined as *the* quantity which obeys the respective conservation principle! For $\mathbf{v}$ = const., the kinetic energy is trivially conserved, but for one particle, this adds nothing to the already known and equally trivial conservation of linear momentum. To change $\mathbf{v}$, one needs at least one more *interacting* particle, the change of $\mathbf{p}$ being then ascribed to a two-body force , $\mathbf{F}_{12}$, *obeying the principle of simultaneous equality of action and reaction at-a-distance*:

$$\mathbf{F}_{12}(r_{12}, t) = -\mathbf{F}_{21}(r_{21}, t) .$$

We stress that the conservation of linear momentum is tied to the fulfillment of Newton s third law and, in contrast with SRT operationalism, implies *simultaneity at-a-distance*. No conservation law for an extended system is possible without absolute, universal time and simultaneity at-a-distance! SRT which re-defines simultaneity locally, is only compatible with a continuous field theory, in which the conservation laws are valid at a point ($\mathbf{r}$,t) in the form of differential continuity equations. As a matter of fact, the Grassmann-Biot-Savart-Lorentz interaction force between two moving charges the only force law compatible with Maxwellian electrodynamics is an action at-a-distance violating both Newton s third principle *and* the energy-momentum conservation law. This fact lies behind the longtime efforts of Stefan Marinov to build an electrodynamic *perpetuum mobile*. Seen in this light, every failure of Marinov to build this wonderful machine is automatically an argument against the Maxwell-Lorentz electrodynamics! This, however, should not mean that the demonstration of a *perpetuum mobile* actually provides further support to Maxwell s theory. If Marinov succeeded in demonstrating a self-accelerating machine, he would have detected a principle of local energy tapping in an open system (see Appendix). By definition, Newton s third law is strictly fulfilled in a closed system. Special relativity is unable to define a system, let alone distinguish between an open and a closed system.

3. The Mass-Energy Relationship

The history of $E = mc^2$ (the only relationship where the velocity of light, *c*, enters mechanics) started with Wilhelm Weber (1846, 1848, 1893) who defined the electromagnetic mass of an interacting pair of charges *e,e* with mutual distance *r* from the *potential energy* (!) as: $m_e = ee'/4\pi\varepsilon_0 rc^2$ with ε_0 the free space permittivity. Remarkably, applied to the parameters of the hydrogen atom, this formula yields $\alpha^2 m_e$ as mass equivalent for the potential energy with α the fine structure constant and m_e the electron mass.

That free radiation characterized by the Poynting vector $\mathbf{S} = \mathbf{E}\otimes\mathbf{H} = E_{rad}\,\mathbf{c}$ and by the energy density $w = (\mathbf{ED} + \mathbf{HB})/2$ possesses linear momentum density $\mathbf{D}\otimes\mathbf{B}$ and inertial mass density $m = |\mathbf{D}\otimes\mathbf{B}|/c = |\mathbf{S}|/c^2$ was no secret for Poincaré (1892).

Poincaré also calculated the recoil of an object with mass M and velocity $\mathbf{V}$ due to the emission of radiation, from linear momentum balance $M\mathbf{V} = \mathbf{S}/c$. The idea that radiation has inertia was already familiar to Maxwell, who derived the magnitude of the force acting on a body due to absorption of radiation power: $f = dE_{rad}/c\ dt$. More important, Adolfo Bartoli (1876) gave a purely *thermodynamic* derivation. Indeed he has shown that, when radiant energy is transported from a hot body to a cold one by means of a moving mirror, the second law of thermodynamics would be violated unless a pressure were exerted on the mirror by the light. Einstein s way to arrive at $E = mc^2$ consisted in viewing a point-like particle emitting two photons in opposite directions, first in the particle s proper frame and then in a frame moving with uniform velocity to the particle. Einstein s derivation, like that of all his predecessors, involved *radiation from charged masses*.

Feigenbaum and Mermin (1988) tried to rid the discussion of radiation altogether and to give a purely mechanical derivation of $E = mc^2$. Their *gedanken experiment* involved a body emitting two massive particles in opposite directions instead of two photons. Then, in a frame of reference moving with velocity $\mathbf{v}$ at an angle θ to the direction of motion of the body, its speed $\mathbf{u}$ satisfies $\gamma(u') = \gamma(u)\gamma(v)(1 - uv\cos\theta)$ with $\gamma = \left(1 - v^2/c^2\right)^{-1/2}$ the famous γ factor. This mechanical or rather *kinematical* formula should have replaced the electromagnetic process of two-photon emission imagined by Einstein (1905). This attempt to avoid non-mechanical concepts is, however, ineffective since *light is hidden* within the radar velocities employed. These velocities, measured supposedly by means of electromagnetic signals with to-and fro-velocities *equal per decree*, are upper bounded by the light velocity *c* and obey an addition law that is non-commutative in (3 + 1) dimensions of space (3) and time (1). On top of it, radar velocities are of no use where microparticles are concerned. The unphysical nature of both Einstein s and Feigenbaum-Mermin s *gedanken experiments* reveals itself if we ask ourselves what the photon or (massive) particle emitting body should be? Clearly, a point-like , structureless particle cannot emit photons, let alone other particles. If, however, the emitting body is a *structured*, *complex* system then the change in internal configurational energy ΔE_{conf} necessarily comes into play and destroys Einstein s and Mermin s energy balance: $\Delta E + \Delta E_{conf} > c^2\Delta m$, as already pointed out by Sachs (1973). A less known, but not objection-free derivation was proposed in 1969 by J. Smulsky (1994). Like in Tsiolkovskii s rocket problem, he imagined a particle with initial mass m_o emitting particles with velocity u. Defining the object s proper energy as the work performed by the *reactive force* $\mathbf{R} = \mathbf{u}dm/dt$, he obtains: $E_o = \int R ds = \int Rv dt = u\int v dm$. Making use of Tsiolkovskii s formula $v = u\ln(m_o/m)$ he gets $E_o = u^2\int dm\ln(m_o/m) = m_o u^2$. If the emitted particles are photons, $E_o = m_o c^2$ follows. This derivation, which assumes *ballistic emission* of photons, brings most forcefully to light the so-called *radiation paradox* (Aspden 1969, 1980): *the derivation of* $E_o = m_o c^2$ *assumes radiation by necessity, while the derivation of* $m = \gamma m_o$ *from* $dE = c^2 dm = \mathbf{F}ds$ *and* $\mathbf{F} = \mathbf{v}dm/dt + m d\mathbf{v}/dt$ *categorically forbids radiation by the accelerated charge*!

The derivation based on de Broglie s ideas (Galeczki 1993) $E \equiv pv_{phase} = mv_{group}\,v_{phase}$ which postulates $v_{group}\,v_{phase} = c^2$ for both photons and massive particles, seems to hold independently of the particles possible charge, but its validity for $v_{group} = 0$ (particle at rest) is questionable. Last but not least, the self-closed toroidal electromagnetic field model for a charged particle with spin which unifies matter and radiation: radiation ≡ free electromagnetic field; matter ≡ closed electromagnetic field defines rest mass as total electromagnetic energy density divided by c^2 (Bergman and Wesley 1990). This spinning ring model is unique in that it accounts for a particle s half-integer spin and internal frequency $\nu_o = m_o c^2/h$ (with h Planck s constant) and provides a self-consistent justification of the rest mass as E_o/c^2.

4. The Configurational Energy

SRT defines energy for free point-like particles as the sum of kinetic and rest contributions: $E = (\gamma \ 1)m_o \ c^2 + m_o \ c^2$. No orthodox book on SRT (and the overwhelming majority of SRT books *are* orthodox) dares to mention potential energy and even less its mass equivalent . This is really strange, if we recall that Weber first mentioned mc^2 as the equivalent of the potential energy of a *charge pair*. Since no *physical system* can be defined without the concept of *configurational energy*, the neglect of this energy by special relativists is really pathological. For the sake of clarity, we use for the *internal* configurational energy of a *bound system* the designation bonding energy , while keeping the name *potential energy* for the *external configurational energy* associated with the interaction of a given sub-system with the larger external system to which it belongs. Potential energy as such is foreign to SRT since on one hand the (relative) position dependent potential energy implies instantaneous action at-a-distance, and on the other hand, velocity-dependent potentials like that introduced by Weber are not in use. With such velocity-dependent potentials, however, the very division of energy in kinetic and potential parts is, rigorously speaking, impossible and actually meaningless.

There are three scenarios to which the already defined concepts apply: *fusion*, *emission of radiation*, and *fission*. In all cases one assumes:

(a) separability of a system s total energy in rest, kinetic, and configurational energy;
(b) the possibility of defining a center of mass and/or a rest mass of the system as-a-whole .

In the case of fusion, $E_{conf} = c^2 \Delta m - \sum E_{kin}$ with $\Delta m = M_o - \sum m_{oi}$ M_o and m_{oi}; the system and single particle rest masses, respectively. If a system radiates energy E_γ, both the system s rest mass and its binding energy are changing:

$$c^2 \Delta M_o + \Delta E_{conf} = E_\gamma > \Delta M_o \text{ where } \Delta M_o = M_{oi}^{n} \quad M_{oi}^{fin}$$

is the mass difference between the initial and the final state. The equality $c^2 \Delta M_o = E_\gamma$ requires $E_{conf} = 0$, which is unphysical. Nuclear fission (in which not even the fragments resulting from the process are unique) is the most complicated case, since it involves three unknown configurational energies: that of the initial nucleus and those of the fission fragments. For this case, Heisenberg s remark turns out to be prophetical (Heisenberg 1990):

> *It has been claimed that the tremendous amounts of energy in atomic explosions are a direct consequence of mass being converted into energy and that the theory of relativity was the only way to understand these huge amounts of energy. This view is based on a misunderstanding. The great amounts of energy stored in atomic nuclei were known since the experiments of Becquerel, Curie, and Rutherford... The energy liberated during an atomic explosion stems directly from this source and does not originate from the conversion of mass into energy.*

The two processes seeming to support the idea of free trade between mass and energy, *production* and *annihilation* of electron-positron pairs are definitely more complex than suggested by the simple symbolic reaction formulae preached in the textbooks, such as $\gamma \rightarrow e \ + e^+$. The production of a pair $(e \, e^+)$ out of a photon requires more than just the right amount of threshold energy $2m_oc^2$: For the system $(e \, e^+)$ we can always define a center of mass with respect to which the total momentum vanishes; this is impossible for the photon γ which does not have such a proper system . Some textbooks state that a third particle is needed for momentum conservation; it seems that the reaction always takes place in the vicinity of a strong nuclear electric field which has great influence on the configurational energy of the *whole system*. In the case of $(e \, e^+)$ annihilation the formation of a *bound system* rather than the production of pure radiation is highly probable. The assumption of the existence of bound electron-positron pairs is a senseful hypothesis avoiding the difficulties associated with the creation of rest mass from any form of energy and of two charges from nothing. These pairs, neutral and with mass much smaller than that of neutrons cannot (or not easily) be detected by current experimental means; even more regrettably, the annihilation-creation model which does not consider their existence *a priori* excludes the motivation to look for them. In the bound-pair model, the threshold energy $2m_oc^2$ corresponds to the *binding energy* of the pair in the spirit of Weber s ideas of the equivalence of mass and potential energy. The revival of Weber s ideas is superior to the *creatio ex nihilo* in that it corresponds to the physical principle of conservation of particles and charges.

5. Action Revisited

Quantum mechanics is the part of physics based on Planck s constant symbolizing a smallest *finite* portion of action, h. In spite of its obviously elementary role in physics, action has not yet been given the consideration it deserves. Physically, action makes sense only if different forms of energy exist on an equal footing and can be converted into each other.

Action is the key to the problem *why* different forms of energy are convertible into each other and *how* this process is realized by Nature.

If energy has inertia as stated by $E = mc^2$ (and there is some experimental evidence in support of this idea) then it is quite natural to attribute a *finite characteristic time* to the mutual conversion between different forms of energy. Moreover, certain observations suggest we assume that the *efficiency* of action itself is a function of absolute velocity. Consider *e.g.* somebody pedaling on a bike; he will find himself wasting his efforts more and more as he increases his velocity. The useful transmission of the energy he pumps in the system (quite independent of frictional losses) asymptotically fades away. The divergence of inertia as v approaches c is the most striking example for this asymptotic decay of efficiency in the regime of extremely high velocities. Formally, this decay of action efficiency at very high energies can be modelled by a velocity dependent inertia, $m(v)$, or by a velocity-dependent force.

The evidence in favour of $E = mc^2$ up to now relies on a few experimental data like those presented by Bertozzi (1964) for energy of *absolute* motion (kinetic energy) based on an *independent* determination of the *time-of-flight velocity* of the particles. In line with our reasoning about ubiquitous action as the basis of energy conversion, we here speculate that it may hold as well for any other form of energy. By its physical dimension, action is the product of energy and time, but this remains a mere abstraction from physics unless that time which must be some *characteristic* time is specified for the energy conversion process (Marquardt and Galeczki 1995). For example, in order to usefully exploit the earth s rotation by means of Foucault-pendulum-type devices (Ruderfer 1983), the characteristic time should be much shorter than it actually is (86,400 seconds). This makes such devices unfit for practical applications. For the same reason, the definition of the efficiency of the Carnot cycle is non-practical since the characteristic time of the assumedly quasi-static process is infinitely long (Wesley 1991).

It should be borne in mind that energy expressed as a product of h and some frequency ν is *not* a quantum unless ν represents some definitely *fixed* value. (This, by the way, casts serious doubts on the Copenhagen interpretation which insists on *intrinsic* uncertainties of all physical phenomena, and hence is in contrast to a true quantum theory). And, unlike in the mysterious interpretation of de Broglie waves as a probability phenomenon , that frequency should have a *physical* meaning too. The most natural occurrence of a frequency is by means of *rotation*. In fact, all matter, from elementary particles to systems of galaxies is found to rotate. Rotation seems to be the preferred type of motion in our universe. (Special relativity addresses only uniform rectilinear motion, which is an unphysical restriction, unless justified as a *local approximation*). The physical dimension of angular momentum being equal to the energy-time product strongly suggests that rotation may be intimately related to action.

6. Conclusions

Contrary to common belief, there exists no objection-free derivation of $E = mc^2$ in general; let alone, a special relativistic one. The derivation relying on de Broglie s ideas requires:

(a) non-dispersive propagation of photons ($m_o = 0$)
(b) dispersion of massive ($m_o \neq 0$) particles in the same vacuum ...

Anyhow, SRT provides no way to derive $E = mc^2$ for potential energy, since SRT has no place for (relative) position-dependent potentials at all. That a moving particle has a kinetic mass and an associated, localized kinetic energy is trivially true. A non-interacting point-like particle (as is always assumed by SRT), however, can by no means have a rest energy . Provided the particle has an internal structure, such an energy can be identified with an internal energy E_o. In such cases, the rest mass could be defined as E_o/c^2. For the rotating ring electron model, the internal energy equals the electromagnetic energy of the self-trapped photon. Once E_o " $m_o c^2$ is accepted for all particles, the energy-mass conservation of SRT boils down to the conservation of total (*i.e.* kinetic + potential) energy of classical dynamics. The mass defect is due to the conversion of binding energy into kinetic energy

Appendix: Prospects for Local Energy Tapping

Many theologians and philosophers have become involved in hot discussions concerning the origin of the initial impulse in the Universe. Ironically, the tremendous progress of science and technology has failed up to now to bring us closer to an understanding of the ubiquitous *cyclic motion* from clusters of galaxies down to atomic electrons, nucleons, and their components. Rotational, rather than linear motion seems to be one of the most characteristic features of the material world. Microscopic ferromagnetism, in particular, has amply confirmed Ampère s brilliant idea of closed persistent molecular currents . In view of the highly successful spinning ring model of the electron (Bergman and Wesley 1990), even the electron spin is a result of a toroidal closed *rotating* electromagnetic field. All microscopic rotations (*e.g.* of electrons in atoms, of spin , of nuclei) are *non-dissipative* and seemingly eternal. A piece of spontaneously magnetized material is very sensitive to the ambient temperature, which has to be lower than the Curie temperature, but untiring and unexhaustible as far as internal rotation is concerned. A permanent magnet can sustain a levitating piece of soft iron for arbitrary time without showing any sign of fatigue . No wonder that all serious candidates to perpetual motion machines consist of a *rotor*, a stator, and *permanent magnets* (Johnson, Ecklin, Bruce de Palma, Tewari, Marinov). Since the US patent office accepts perpetual motion inventions only if supported by a working model, these patents represent public proof of their feasibility. Since local rotation is a manifestation of the interconnectedness of the universe as a whole, the utilization of machines involving rapid rotations *and* permanent magnets could well be termed *local tapping of energy*. On the macroscopic scale, we know of another striking example for the pairing of a permanent source and a permanent rotor working together as a seemingly inexhaustible energy source: the production of tidal waves due to the combined effects of moon s (and to a lesser extend sun s) gravity and earth s rotation. Both, the source of gravity (moon) and the rotor (earth) do not show any detectable sign of exhaustion . Apparently, the combination of a permanent (magnetic, gravitational or electric-type) *source and a rotating subsystem* is worthwhile to be considered as the key for good prospects of energy tapping. We conclude in formal terms that the configurational energy which, to a good approximation, is a function of relative positions and velocities, becomes *modulated* in a higher approximation due to the *absolute rotations* of the component subsystems.

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