Chapter 6
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Relation between Planck's Constant and Speed of Light, Predicting Proton Radius More Accurately

Anna C. M. Backerra[1*]

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ABSTRACT

Twin physics is a new physical model in which the basic features of quantum mechanics and relativity theory are combined to a manageable description, which can be represented geometrically. In this model, descriptions of phenomena on a quantum-mechanical scale can be combined with those at an astronomical scale by considering them in a complementary way. This is in agreement with the view of Heisenberg and carried out by using the definition of complementarity as given by Max Jammer.
The obtained theoretical results can be identified with basic physical phenomena like the forces of nature, a series of elementary particles and gravitational waves. If the proton, as described by twin physics, is combined with the early ideas of Einstein about the energetic equivalence of mass and radiation, a relation between the Planck's constant and the speed of light is found, in which the mass and the radius of the proton occur. In this relation also a factor four appears, being an integer, which is acting as a conversion factor from mass to radiation. Besides of that, the relation leads to a more accurate prediction of the radius of the proton.

Keywords: Complementarity; special relativity; Planck's constant; proton radius; proton spin; speed of light.

1. INTRODUCTION

Twin physics is a model based upon one physical and one mathematical starting point. The ***physical*** starting point is the uncertainty relation of Heisenberg [1] describing uncertainty at a subatomic scale, extended with his later conviction [2] that the physical world is ***complementary*** at all scales. As an example, by considering space as an independent energetic item, it is possible to consider mass and free space as complementary objects: ***Mass*** occupying a relatively small space, having an extremely high energy density, and ***free space*** occupying a relatively large space, having an extremely low energy density.

The ***mathematical*** starting point is the definition of complementarity developed by Jammer [3] based upon the mathematical work of Weizsäcker [4] providing a scientific gateway to a complementary view on physics. A definition like this was not yet available at the beginning of quantum mechanics, when uncertainty and indeterminism unexpectedly popped up in a deterministic oriented scientific world. At the time the only alternative to tackle uncertainty was probability theory, but this could not go into the details.

To these two starting points we added the concept of a ***unit of potential energy***, instead of taking an elementary particle as the basic unity. This is called a Heisenberg-unit (H-unit), an abstract concept without a physical meaning on its own, because potential energy cannot be observed. Potential energy is merely a mathematical intermediate to be able to calculate the conversion of one type of real energy into another one. In twin physics any mathematical description of the physical universe is based merely upon interacting H-units.

[1]Stichting de Schat, Gualtherus Sylvanusstraat 2, 7412 DM Deventer, The Netherlands.
**Corresponding author: E-mail: annabackerra@gmail.com*

By definition, the potential energy of an H-unit can be converted into an actual energetic object only by ***interacting*** with another H-unit, so the basic idea of relativity theory is incorporated from scratch. The type of interaction and so the resulting phenomenon is completely decided by the relative distance between these two H-units. The H-unit is a bridge between large- and small-scale physics as it is ***defined in two sizes***: a neutral one being of astronomical size and a marked one of molecular size or maybe somewhat larger. Two H-units of different sizes may interact without any mathematical problem, because the central formula (the zipper) is constructed such, that incompatible items will be reduced to reconcilable ones. An interacting H-unit may be converted partly as well as totally into real energy. If not all potential energy is used in an interaction, it may interact simultaneously with another H-unit and convert the remaining amount of potential energy into another energetic object.

The features of one H-unit are expressed by supplying it with ***complementary mathematical items*** of space and time. The interaction between two H-units is formulated by combining these items in all possible ways. The resulting general equation is a set of four possible types of interaction, called the ***zipper***. For each of the two qualities 'three-dimensional space' and 'time' a separate zipper is deduced. A third zipper is deduced for the quality 'mark', being a precursor of charge, electricity and magnetism. For a given relative position of two H-units, each of the zippers of space, time and mark will be decided and after having worked them out, they will be combined into one time-space-mark zipper.

As the last step, the mathematical descriptions inside the zipper will be ***represented in a real physical space and time***. By carrying out this operation, items which have no reflection in the real world, will disappear. This step is a remarkable one, because in the past it was a common conviction that physical laws were congruent with successful mathematics, even if this success was limited. It was the reason that for instance the collapsing wave function of Schrödinger raised a lot of dust. In twin physics, mathematics is considered as a tool for physics; necessary restrictions if applied to physics, are a recognition of the difference between a tool and the subject on which this tool has to work. After having carried out the representations of all items inside the zipper in a real physical space and time, the zipper contains ***maximum two descriptions*** of physical phenomena. After having identified them, they are called ***Heisenberg events*** (H-events).

In 1916, Einstein [5] used four-dimensional spacetime, which was a big success at an astronomic scale, but didn't work at a subatomic scale. Later, in a series of lectures [6] he suggested that the problem might be caused by the ***improper use of it at a subatomic scale***. For that reason, we use three-dimensional space and one-dimensional time separately, but to stay as close as possible to his results, we treat space and time ***mathematically*** in the same way. Besides, Einstein's attention for geometric descriptions like in ancient Greece, inspired us to describe objects in a ***geometric*** way. This is facilitated by using ***set theory*** of Kahn [7] because according to this mathematical theory, items with different dimensions, like space and time, may be combined in one expression.

In this way the four forces of nature are described, as well as two types of protons, three types of neutrons, four types of electrons [8], two types of free spaces, neutron decay in detail and gravitational waves. Encouraging details are that the ***laws of Maxwell can be derived*** in a staggering short way, and that the ***constancy of the speed of light***, as well as the existence of the ***constant of Planck*** can be derived without using a postulate.

All basic information about twin physics can be found in the book 'Twin physics, the complementary model of phenomena' of Backerra [9]. The original development of twin physics can be found subsequently in six publications [10,11,12,13,14,15]. The fifth paper [14] starts with a short manual for using twin physics; in the sixth paper, equations for all possible cases of time and space are listed in the index [15].

The basics of this model are rather difficult to grasp, as it requires a fundamentally new way of thinking. On the contrary, as soon as its principles are well understood, it is a rather easy way to find a theoretical background for many experimental situations, without the necessity to go deep into the theory. As a help, two papers are written as an introduction in a more accessible way. The first is written to become more acquainted with the structure of twin physics [8], showing the resulting geometric representations of described objects and possible future applications on nanophysics without showing all underlying equations. In the second paper [16], for a quick understanding of the derivation of the zipper the attributes of space are represented by colored blocks, offering a ***didactic shortcut***; also a link to a video presentation is given.

In this paper we will investigate the connection between a specific theoretical result of twin physics, being the description of a proton, in combination with the early ideas of Einstein [17], because we are on the search for a relation between mass and free space. The essential point is that, according to twin physics, a tiny, magnetized particle called spin particle exists at the surface of the proton, turning across it and providing the proton with a magnetic spin. This rather surveyable deduction leads to an astonishing simple relationship between a single proton and an energetic similar set of photons, revealing the potential existence of an energetic, free space around the proton.

In the next section we will go rather swift through the theoretical basics, as a kind of reminder or as a first impression, before concentrating on the proton.

2. BASICS OF TWIN PHYSICS

We distinguish three basic qualities of phenomena, being three-dimensional space $\mathbf{x}$, time t and mark q (a precursor of charges and fields). In this paper the attention will be almost completely directed to space; some previous results about time and mark will be used if necessary.

The definition of complementarity given by Jammer [3] gives four conditions for a complementary interpretation of two descriptions A and B:

"A given theory admits a complementary interpretation if the following conditions are satisfied:

(a). It contains (at least) two descriptions A and B of its substance- matter;
(b). A and B refer to the same universe of discourse;
(c). Neither A nor B, if taken alone, accounts exhaustively for all phenomena of this universe;
(d). A and B are mutually exclusive in the sense that their combination into a single description would lead to logical contradictions."

We apply this definition to define suitable mathematical ***space attributes*** for each H-unit, such, that later in the deduction optimal physical descriptions will be obtained. For A we take ***point of space*** $\widetilde{P}_i$ in the middle of finite spherical space $\widetilde{S}^i$; for B we take ***the same space, point*** $\widetilde{P}_i$ ***excluded***, written as $\widetilde{S}^i \backslash \widetilde{P}_i$. These two attributes satisfy the conditions mentioned above. Lower indices indicate determinate attributes, higher indices indeterminate ones. Point $\widetilde{P}_i$ obviously is a determinate attribute; space $\widetilde{S}^i \backslash \widetilde{P}_i$ is an indeterminate attribute because it is defined as an independent object, not as a collection of points, and so containing no specific location. The tildes indicate mathematical attributes; after transforming into a three-dimensional physical attributes, the tildes will be removed.

Next we involve the ***Heisenberg principle*** in a complementary way. This principle says that each observation of certainty implies a small amount of uncertainty at an atomic scale. This implies that certainty and uncertainty do not have the same importance: one dominates the observation and the other is a relatively small addition. To realize this difference in importance, we consider the two attributes above as ***major attributes*** of space and define two additional complementary ***minor attributes***. These are a tiny sphere $\tilde{s}^i$ around point $\widetilde{P}_i$, called ***minor space***, and an infinitesimally thin layer $\tilde{p}_i$ upon this minor space, called ***pellicle***. Together they satisfy the conditions. Pellicle $\tilde{p}_i$ is a determinate attribute because it is a collection of points having the same distance to $\widetilde{P}_i$ (with an infinitesimal variation). Minor space $\tilde{s}^i$ is an indeterminate attribute for the same reason as the major space.

The major determinate attribute together with the minor indeterminate one is suited to express the Heisenberg relation. The major indeterminate attribute together with the minor determinate one is suited to express that each observation of ***uncertainty*** implies a small amount of ***certainty***, so to express the complement of the original relation. This is called the *extended Heisenberg* principle.

The four attributes of space, two by two being complementary, are collected in the set of space attributes $h_i\left(\tilde{\mathbf{x}}\right)$

$$h_i\left(\tilde{\mathbf{x}}\right)=\left\{\tilde{P}_i\,,\tilde{S}^i\setminus\tilde{P}_i\,,\tilde{p}_i\,,\tilde{s}^i\right\}\,. \tag{1}$$

Fig. 1 is a schematic, geometric representation of equation (1). Although at a first glance it may look complicated, it is mainly a correction of the approximation of ***Newton*** for space and mass. Newton considered space as infinite and an elementary mass as a point. In the set of space attributes (1), major space $\tilde{S}^i\setminus\tilde{P}_i$ is finite, but still it has an astronomic size (if it carries no fields, which will be considered later) and so it may be considered as a ***restriction*** of Newtons infinite space. Minor space $\tilde{s}^i$ has an atomic or molecular size; later we will see that this may transform into an elementary solid particle and so it is an ***extension*** of point $\tilde{P}_i$. This is in accordance with the present-day experimental knowledge that mass occupies some space. Nevertheless, point $\tilde{P}_i$ is still necessary in the set, because eventually a charge has to be attached to it.

The complementarity of the set of attributes (1) is completed by a fourth attribute, the skin of the minor space, called the ***pellicle*** $\tilde{p}_i$. This is the only fundamentally ***new item***, not being related to the starting points of Newton, nor to mass measurements. The pellicle is added as the minor determinate space attribute because of our first starting point, being the ***overall complementarity*** in physics, reflected in the set of attributes (1). This originates in the quantum mechanical experiments of 1927 [18], showing a principle duality in physics by the incompatibility of the particle- and wave-character of an electron. Self-evidently the pellicle plays the main role in our search for a connection between mass and free space.

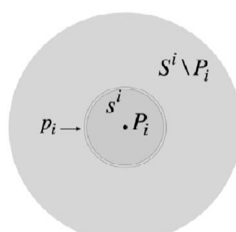

Fig. 1. Schematic, geometrical representation of the set of space attributes

As the unit in twin physics, we have chosen for a ***unit of potential energy*** called the ***Heisenberg-unit***, in short written as H-unit. Potential energy is no physical item, as it cannot be measured without being canceled. It is a mathematical item, describing the conversion of actual energy from one type into another. By definition the H-unit can convert into actual energy only by ***interaction*** with another H-unit, and so relativity theory is incorporated from scratch.

An interaction between two H-units H_i and H_j is in general written as $H_i * H_j$, expressed in combinations of their attributes. The two sets of space attributes are subsequently indicated by $h_i\left(\tilde{\mathbf{x}}\right)$ and $h_j\left(\tilde{\mathbf{x}}\right)$, subsequently. A thorough deduction of this expression is given in [9]. An easy introduction in which the attributes - as a didactic shortcut - are represented by colored blocks, can be found in [16], including a video.

The ***space interaction*** of H_i and H_j can be described by all allowed combinations of their eight attributes, using appropriate operators. This is a huge amount, but fortunately there is a severe restriction. The experimental fact in quantum mechanics that the wave- and particle-character of an electron never can be observed simultaneously, implies that the ***two major attributes*** of one and the same H-unit ***never can be observed simultaneously***. This reduces the amount of possible combinations drastically to only four allowed combinations.

Then all existing mathematical information about the space interaction between H_i and H_j can be collected in a set of four elements, called the *space zipper* $Z_{ij}(\mathbf{x})$:

$$Z_{ij}(\mathbf{x}) = \left\{ \begin{array}{l} \left\{ \left[\tilde{P}_i \cap \tilde{P}_j \right], \left[\tilde{s}^i \cap \tilde{s}^j \cap \left(\tilde{P}_i \bowtie \tilde{s}^j \right) \cap \left(\tilde{P}_j \bowtie \tilde{s}^i \right) \right] \right\} \\ \left\{ \left[\left(\tilde{S}^i \backslash \tilde{P}_i \right) \cap \left(\tilde{S}^j \backslash \tilde{P}_j \right) \right], \left[\tilde{p}_i \cap \tilde{p}_j \cap \left(\tilde{S}^i \backslash \tilde{P}_i \bowtie \tilde{p}_j \right) \cap \left(\tilde{S}^j \backslash \tilde{P}_j \bowtie \tilde{p}_i \right) \right] \right\} \\ \left\{ \left[\tilde{P}_i \cap \left(\tilde{S}^j \backslash \tilde{P}_j \right) \right], \left[\tilde{s}^i \cap \tilde{p}_j \cap \left(\tilde{P}_i \bowtie \tilde{p}_j \right) \cap \left(\tilde{S}^j \backslash \tilde{P}_j \bowtie \tilde{s}^i \right) \right] \right\} \\ \left\{ \left[\tilde{P}_j \cap \left(\tilde{S}^i \backslash \tilde{P}_i \right) \right], \left[\tilde{s}^j \cap \tilde{p}_i \cap \left(\tilde{P}_j \bowtie \tilde{p}_i \right) \cap \left(\tilde{S}^i \backslash \tilde{P}_i \bowtie \tilde{s}^j \right) \right] \right\} \end{array} \right\} \tag{2}$$

Each element of the zipper (one horizontal line in equation (2)) is called a *space zip* $z_n(\mathbf{x})$, with $n \in \{1, 2, 3, 4\}$, representing one type of interaction. Usually only one or two zips are non-empty; if two H-units have not even partly overlapping major spaces, they have no interaction at all and so the zipper is empty.

When looking closer, we see that each non-empty zip is again a set, containing two elements describing subsequently the large- and small-scale aspect of the interaction. The square brackets around each element indicate that the mathematical items in between of them have to be transformed in a three-dimensional physical space, according to some obvious rules. If this is possible, then the two transformed aspects of each zip have to be reconciled to a ***single physical description*** and then an appropriate amount of *actual energy* will be ascribed to it. After doing the same with an eventual second non-empty zip, the description of one or two physical objects is obtained. The generated actual energy depends on the involved items and is proportional to the size of the overlapping regions. This is decided by the ***distance of their major points of space*** $\tilde{P}_i$ and $\tilde{P}_j$.

An important feature of the zipper is, that two appearances of one and the same interaction have ***the same actual energy***. This can be explained as follows. If the potential space energy of one H-unit is written as constant *V*, then the available potential space energy of the interaction between two H-units is $2 \times V$. In general only a fraction *x* (with $0 < x \leq 1$) of it will be conversed, so the actual space energy is equal to $x \times 2 \times V$. Because the dual behavior of electrons in quantum mechanical experiments is anchored in the basics of twin physics, the two appearances cannot be observed simultaneously and thus each of them represents the interaction fully, generating the same amount of space energy $x \times 2 \times V$.

So, if the zipper describes two objects, the same amount of actual energy will be ascribed to each of them and because they never can be observed simultaneously, a double amount of energy never can appear. The described physical objects may be a point, a sphere or an intersection of spheres.

Most ***transformations*** from mathematical to physical descriptions are described by just removing the tildes.

The transformation of mathematical point of space $\widetilde{P}_i$ is called a ***real point of space***, written as:

$$[\widetilde{P}_i] = P_i \ , \tag{3}$$

The transformation of the major space $\widetilde{S}^i \backslash \widetilde{P}_i$ is called a ***macrospace***, written as:

$$[\widetilde{S}^i \backslash \widetilde{P}_i] = \Theta\left(S^i \backslash P_i\right) \ . \tag{4}$$

The transformation of a minor space $\widetilde{s}^i$ is called a ***microspace***, written as:

$$\left[\widetilde{s}^i\right] = \theta\left(s^i\right) . \tag{5}$$

The transformation of a pellicle $\widetilde{p}_i$ is an exception; it cannot be transformed into a physical pellicle, as this is a singular object. In case two pellicles are coinciding, then this transformation is defined as a tiny spherical space inside the coinciding pellicles. This tiny sphere is called a ***pelletspace***, having a diameter equal to the width of a pellicle and written as:

$$\left[\widetilde{p}^i\right] = \circ\left(p_i\right) \ . \tag{6}$$

If the two pellicles are not coinciding but only intersecting, the pelletspace exists inside the intersection, in general being a ring; we will not consider it here.

After transforming the large- and the small-scale elements of one specific zip, the resulting two items (one large-scale and one small-scale) have to be ***reconciled*** with each other, to obtain the description of a ***single physical object***. After ascribing energy to this object, a physical ***appearance*** Ω_n is obtained. In general, the first zip appears as a solid particle, the second as a free space or as a much smaller particle (like for instance a neutrino), the third as an electron and the fourth as a photon.

The ***time zipper*** $Z_{ij}\left(t\right)$ is deduced by changing the three-dimensional space attributes into one-dimensional time attributes, obtaining:

$$h_i\left(\widetilde{t}\right) = \left\{\widetilde{T}_i, \widetilde{F}^i \backslash \widetilde{T}_i, \widetilde{\tau}_i, \widetilde{f}^i\right\} \tag{7}$$

Again three of these four attributes are rather common, being subsequently **a *point of time*** $\widetilde{T}_i$, a finite ***future*** $F^i \backslash T_i$ and a ***time derivative*** τ_i. A new item, analogous to the minor space, is the ***flying time*** f^i, describing uncertainty of time at a small scale. This is in agreement with the experimental fact that any measurement of time is *cyclic* and so the interval of time between two measured points never can be measured, no matter how small it may be. The flying time is conceived as an ***extended presence***. Each ***time zip*** $z_n\left(t\right)$ contains information if the object, described by the corresponding space zip $z_n\left(\mathbf{x}\right)$, having the same value of *n*, is static or dynamic, moving with a constant velocity or in acceleration, or not existing at all. We will not show the general time zipper, but use in the following example only the specific time zipper in the considered case. All time zippers can be found in the appendices of [9] and [15].

An H-unit may also be supplied with a ***set of mark attributes***, suited to describe ***charge and fields***; then the H-unit is called a marked (or charged) H-unit. The essential meaning of marking is to create an identification and this may be compared with voting: you agree (+), you don't agree (-) or you don't mind (0). Because the H-unit has to spend potential energy to charge and fields, it has less potential energy to generate spaces, so the spaces of a marked H-unit are much smaller than those of a neutral H-unit. We suppose that the radius of the marked major space is in the order of the size of molecules or somewhat larger.

To be able to mark point of space $\widetilde{P}_i$ in a complementary way, the mark set contains two charges, being real number $\widetilde{Q}_i$ (a determinate charge) and imaginary number $i \times \widetilde{Q}_i$ with *i* being the imaginary unit (an indeterminate charge). To be able to mark major space $\widetilde{S}^i \backslash \widetilde{P}_i$ in a complementary way, the set contains two fields, being ***radial field*** $\widetilde{\mathbf{E}}_i$ (a determinate field) and ***circular field*** $\widetilde{\mathbf{B}}^i$ (an indeterminate field). Both determinate items are collected in the set of two elements $\left\{\widetilde{Q}_i, \widetilde{\mathbf{E}}_i\right\}$, being the ***major determinate*** element of the set of mark attributes. Both indeterminate items are collected in the set of two elements $\left\{\widetilde{Q}_i \times i, \widetilde{\mathbf{B}}^i\right\}$, being the ***major indeterminate*** element of the set of mark attributes. For completeness we mention that the determinate and indeterminate *minor* attributes are subsequently $\left\{1, \widetilde{\nabla}\right\}$ and $\left\{i, \partial/\partial\tilde{t}\right\}$.

Although these attributes are very different from the space and time attributes, the mark ***zipper*** $Z_{ij}(q)$ has a similar structure as the space and time zippers. For the complete deduction of the mark attributes and zipper, see [9]. After transformation into a physical space, real charges are attached to available real points of space. Real fields are connected to available real spaces and this implies that, although the mathematics of the electric and magnetic fields reach to infinity, the physical appearances of the fields are restricted to finite spaces.

Each ***mark zip*** $z_n(q)$ contains information if an object described by the belonging space zip $z_n(\mathbf{x})$, having the same value of *n* , is charged or is carrying a field or an electromagnetic vector. We will not show the general mark zipper, but use in the following example only the specific mark zipper in the considered case; all mark zippers can be found in the appendix of [9].

3. THE PROTON AND ITS SPIN PARTICLE

We consider two positively marked, coinciding H-units; this is called ***space case 1.*** We will consider first the space zipper in a more extended way; after that, the time and the mark zippers will subsequently be included in the consideration. According to space zipper (2), in the coinciding case space zips $z_3(\mathbf{x})$ and $z_4(\mathbf{x})$ are empty, and so the *space zipper* reduces to the set of two elements:

$$Z_{ij}(\mathbf{x}) = \left\{z_1(\mathbf{x}), z_2(\mathbf{x})\right\} = \left\{ \begin{array}{l} \left\{\left[\widetilde{P}_i\right], \left[\tilde{s}^i\right]\right\} \\ \left\{\left[\widetilde{S}^i \backslash \widetilde{P}_i\right], \left[\tilde{p}_i\right]\right\} \end{array} \right\}. \quad (8)$$

Transforming the mathematical items in between of the square brackets into a three-dimensional physical space, we obtain:

$$Z_{ij}(\mathbf{x}) = \left\{z_1(\mathbf{x}), z_2(\mathbf{x})\right\} = \left\{\left\{P_i, \theta\left(s^i\right)\right\}, \left\{\Theta\left(S^i \backslash P_i\right), \circ\left(p_i\right)\right\}\right\}. \quad (9)$$

The large-scale element at the left of each zip has to be reconciled with the small-scale element at the right, in such a way that both aspects will be represented in one expression. For zip $z_1(\mathbf{x})$ this means that P_i has to be reconciled with $\theta\left(s^i\right)$, and for zip $z_2(\mathbf{x})$ that $\Theta\left(S^i \setminus P_i\right)$ has to be reconciled with $\circ(p_i)$.

In general, the reconciliation of the large-scale ***determinate*** space items with the corresponding small-scale ones is realized by ***uniting them***. Reconciliation of the lage-scale ***indeterminate*** space items with the corresponding small-scale ones is realized by *limiting* them to the overlapped small-scale ones, in general resulting in the small-scale item (see [9] part 2.3). Then space zipper (9) reduces to:

$$Z_{ij}(\mathbf{x})=\left\{P_i \cup \theta\left(s^i\right), \circ(p_i)\right\} . \tag{10}$$

Zip $z_1(\mathbf{x})$ describes real point of space P_i in the center of microspace $\theta\left(s^i\right)$; zip $z_2(\mathbf{x})$ describes a pelletspace $\circ(p_i)$ inside the coinciding pellicles. We cannot identify these objects properly without information about the time-interaction, so we will consider the belonging ***time zipper*** in ***time case 1***. This is simply obtained by substituting the time attributes of equation (7) in equation (8) at similar positions:

$$Z_{ij}(t)=\left\{z_1(t), z_2(t)\right\}=\left\{\begin{array}{l}\left\{\left[\tilde{T}_i\right],\left[\tilde{f}^i\right]\right\} \\ \left\{\left[\tilde{F}^i \setminus \tilde{T}_i\right],\left[d\tilde{t}_i\right]\right\}\end{array}\right\} . \tag{11}$$

After transformation into a real time axis and reconciliating in similar way as for space, time zipper (11) reduces to:

$$Z_{ij}(t)=\left\{T_i \cup f^i, dt\right\} . \tag{12}$$

Then the *time-space zipper* can be written as a combination of equations (10) and (12):

$$Z_{ij}(t, \mathbf{x})=\left\{z_1(t, \mathbf{x}), z_2(t, \mathbf{x})\right\}=\left\{\left\{T_i \cup f^i, P_i \cup \theta\left(s^i\right)\right\},\left\{dt, \circ(p_i)\right\}\right\} . \tag{13}$$

Time is placed before space, because a non-empty time element is the first requirement to obtain any appearance, so we do not have to deduce the space zip if the corresponding time zip is empty. Ascribing energy to each of the two zips, we obtain the set of ***time-space appearances****:*

$$\Omega_{ij}=\left\{\Omega_1(t, \mathbf{x}), \Omega_2(t, \mathbf{x})\right\}=\left\{\sigma_{ij}\left(T_i \cup f^i, P_i \cup \theta\left(s^i\right)\right), \pi_{ij}\left(dt, \circ(p_i)\right)\right\} . \tag{14}$$

The two elements Ω_1 and Ω_2 are called Heisenberg-events; they are generated by interaction $H_i * H_j$. We will identify them as far as possible, but still without considering the influence of the quality mark.

Appearance Ω_1 is identified with ***solid particle*** σ_{ij} , being a proton or a neutron. Its location is real point of space P_i and it occupies microspace $\theta\left(s^i\right)$. Its movement is characterized by $T_i \cup f^i$ which is a point of time united with the flying time, together being the complete present. As the attribute *dt* is missing in this expression, no change can be described and so the particle has a constant velocity. Because we consider only this particle, there is nothing to move to and thus the velocity is zero.

Appearance Ω_2 is identified with ***pellet particle*** π_{ij}, existing at the surface of σ_{ij}. It occupies the infinitesimal pelletspace $\circ(p_i)$, existing somewhere inside the coinciding pellicles at the surface of σ_{ij}. Its movement is characterized by dt, indicating a constant movement. This can only be a movement across the surface of the proton, acting as an infinite two-dimensional space for π_{ij}.

To obtain information about charges and fields, we will consider the first two elements of the ***mark zipper*** in the case that both H-units are marked ***positively***, indicated by H_i^+ and H_j^+; this is ***mark case 1***. This zipper is given without deduction in [9], section 5.1.3, as:

$$Z_{ij}(q)=\left\{z_1(q),z_2(q)\right\}=\left\{\left\{Q_i^+,\widehat{\partial\mathbf{E}_i/\partial t}\right\},\left\{\widehat{\mathbf{B}^i}+\widehat{\mathbf{B}^J},\nabla\times\widehat{\mathbf{B}^i}\right\}\right\}. \quad (15)$$

The rooflets above the field terms indicate that these items are restricted to the spaces as described by the belonging space zipper. Note that the large-scale aspects of the mark zips have ***other dimensions*** than the small-scale aspects. The consequence is that the large- and small-scale field items cannot be reconciled into one expression, as we did with the zips of time and space to obtain the physical appearance. This is no problem, because in the time and space zips, reconciliation was necessary to meet the extended Heisenberg principle; this is only valid for the qualities 'time' and 'space', not for 'mark'.

Real charge Q_i^+ in equation (15) will be attached to real point of space P_i of equation (14). Real field $\widehat{\mathbf{B}^i}+\widehat{\mathbf{B}^J}$ has to be attached to a macrospace Θ (see equation (4)), which is not occurring in equation (14) and thus this field cannot appear. The remaining sub-elements of equation (15) are field derivatives; these will be attached to the small-scale spaces in the corresponding space zips. So electric field derivative $\widehat{\partial\mathbf{E}_i/\partial t}$ is attached to microspace $\theta\left(s^i\right)$ in equation (14), but because this particle has a velocity zero, the derivative is also zero. Field derivative $\nabla\times\widehat{\mathbf{B}^i}$ in equation (15) is attached to pelletspace $\circ(p_i)$ (see equation (6)).

Ascribing energy to those mark elements of equation (15) which can be attached to geometric objects, the set of time-space appearances (14) can be extended to the completed ***time-space-mark set of appearances*** for the coinciding interaction of two positive charged H-units $H_i * H_j$ as:

$$\Omega\left(H_i^+ * H_j^+\right)=\left\{\sigma_{ij}\left(T_i\cup f^i,P_i\cup\theta\left(s^i\right),Q_i^+\right),\pi_{ij}\left(dt,\circ(p_i),\nabla\times\widehat{\mathbf{B}}^i\right)\right\}. \quad (16)$$

In the first H-event, being solid particle σ_{ij}, a charge Q_i^+ appears and so we identify it with a ***proton***.

In the second H-event, pellet particle π_{ij} has magnetic field derivative $\nabla\times\widehat{\mathbf{B}^i}$ inside; we know already that π_{ij} is turning around the proton across its surface, so it supplies the proton with a magnetic spin and for that reason we call it a ***spin particle*** (see Fig.2).

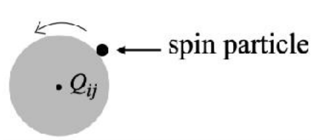

Fig. 2. Geometric representation of the proton with the spin particle moving over its surface

Two appearances generated by one interaction have the ***same energy***, so if E_σ is the energy of σ_{ij} and E_π is the energy of π_{ij}, then:

$$E_\sigma = E_\pi \ . \tag{17}$$

This is only possible if the velocity of the spin particle is high enough, so if the ***rest energy of the proton*** having mass m_σ is equal to the ***relativistic energy of the spin particle*** having mass m_π, which can be written as:

$$m_\sigma \times c^2 = m_\pi \times c^2 \times \frac{1}{\sqrt{1 - v_\pi^2 / c^2}} \tag{18}$$

with *c* being the speed of light. Even if the radius of the proton would be only 10 times the radius of the spin particle, its velocity would differ less than 0.0001% of the speed of light, so $v_\pi \approx c$.

4. MASS AND RADIATION

The origin of the expression at the left side of equation (18) can be found in a famous paper of Einstein [17], in which a system of plane waves with a body in it is described. For better comprehension we will change the original expression for the energy of light *L* into E_r (*r* is for radiation). Then a fragment from this paper is: "If a body gives off the energy E_r in the form of radiation, its mass diminishes by E_r / c^2 ." Later he adds that "the mass changes in the same sense", apparently to explain that, if oppositely the body absorbs energy, its mass will increase.

We will write this as an equation. The mass of the body is indicated by m_b , so the change of mass is Δm_b .

If the body ***gives off*** energy E_r in the form of radiation, then:

$$\Delta m_b = - E_r / c^2 \ , \tag{19}$$

and if the body *absorbs* energy E_r in the form of radiation, then:

$$\Delta m_b = + E_r / c^2 \ . \tag{20}$$

From this he concludes: "The fact that the energy withdrawn from the body becomes energy of radiation evidently makes no difference, so that we are led to the more general conclusion that the mass of a body is a measure of its energy-content."

We will write this also as an equation (b is for body):

$$E_b = m_b \times c^2 \ . \tag{21}$$

Comparing equations (19) and (20) with equation (21), we see that Einstein changes from speaking about the energy of the ***radiation*** (E_r) to the energy of the *body* (E_b), and from the ***change of mass*** Δm_b to the *total mass* m_b. The last sentence of this paper is: "If the theory corresponds to the facts, radiation conveys inertia between the emitting and absorbing bodies."

All together this evokes the suggestion that ***the energy of the body equals the energy of a certain amount of radiation*.**

If only ***one proton*** σ_{ij} is chosen as the body, then $E_b = E_\sigma$. If an equivalent radiation energy is the sum of energies of *N* photons having frequencies υ_n (with $1 \leq n \leq N$), then the proton energy should be equal to:

$$E_\sigma = \sum_{n=1}^{n=N} h \times \upsilon_n \ . \tag{22}$$

The only specific frequency for the proton can be the ***turning frequency of the spin particle*** π_{ij}. It travels once around the proton in a period of time $T = 2\pi \times R_\sigma / c$ (R_σ being the radius of the proton) and so its frequency υ_n is:

$$\upsilon_\pi = c / \left(2\pi \times R_\sigma \right) . \tag{23}$$

If we suppose that radiation, having the same energy as the proton, is in some way or another related to the features of the proton, their relationship can only be anchored in the frequency as given by equation (23). If we suppose that the proton in principle **may *decay into N photons,*** all of them having this same frequency, then (22) reduces to:

$$E_\sigma = N \times h \times \upsilon_\pi \ . \tag{24}$$

Inserting the right part of equation (21) in the left part of equation (24), and inserting equation (23) for υ_n, we obtain:

$$m_\sigma \times c^2 = N \times h \times \frac{c}{2\pi \times R_\sigma} \ , \tag{25}$$

and so:

$$N = \frac{2\pi \times R_\sigma \times m_\sigma \times c}{h} \ . \tag{26}$$

We will use the values $m_\sigma = 1.672623 \times 10^{-27}\ \mathrm{kg}$, $c = 2.997925 \times 10^{8}\ \mathrm{m/s}$, $h = 6.626070 \times 10^{-34}\ \mathrm{J\,s}$ and $\pi = 3.141593$. The radius of the proton R_σ is known not more accurately than $R_\sigma = 0.84 \times 10^{-15}\ \mathrm{m}$.

Inserting these values in equation (26), we obtain $N = 3.994128$. This differs less than 0.15% from integer 4, so we suppose that $N = 4$. It says that the energy of *a **single proton*** is equal to the energy of ***four photons*** of equal frequency $\upsilon_\pi = c / \left(2\pi \times R_\sigma \right)$.

If we insert $N = 4$ in equation (26), without inserting the experimental value of R_σ, we obtain the prediction of a ***more accurate radius of the proton*** as:

$$R_\sigma = 0.841235 \times 10^{-15}\ \mathrm{m} \ . \tag{27}$$

Using this value for R_σ and inserting $N = 4$ in equation (26), which expresses the energetic equality of the proton mass and a certain amount of radiation, this equation turns into a relation between Planck's constant and the speed of light. Using the reduced Planck's constant (the Dirac constant) $\hbar = h/2\pi$ in equation (26), this relation can be written as:

$$c = 4 \times \frac{\hbar}{R_\sigma \times m_\sigma} \quad . \qquad (28)$$

If the predicted value of R_σ experimentally turns out to be valid, then the constants of nature $\hbar = h/2\pi$ and *c* are connected by the mass and the radius of the proton. In that case, according to equation (28), $\hbar$ and *c* cannot be considered as ***independent constants of nature*** anymore.

In order to comprehend the meaning of the maybe surprisingly simple result of the integer 4, we will consider this hypothetical decay of an isolated proton into a collection of photons closer. Because the proton has no intrinsic necessity to move, we suppose that the ***sum of impulses of the photons is zero.*** If we require that the vector points of these impulses stretch out to a mathematical object related to the spherical shape of the proton, they will form a regular polyhedron. As a consequence, their impulses and thus their energies are equal. A sphere is determined by four points, so four photons having equal impulses and forming a *tetrahedron*, are enough to represent the shape of the proton. Different from the unmoving proton, a photon cannot stand still; it has an intrinsic necessity to move with the velocity of light and so it is representing free space. This means that integer 4 is the ***conversion factor from mass to radiation,*** introducing the sense of movement in all directions. It can also be conceived as the conversion from a passive to an active phenomenon. By their extremely active movement, the four photons ***reveal the potential existence of an energetic, free space*** around the unmoving proton. Note that this free space will be restricted, as the photon description in twin physics is based upon the interaction between a charged and a neutral H-unit, having a *finite* major space of astronomic size [13]. More research is needed to expand our view on the role of this factor 4 in physics.

In a previous paper we described the spontaneous decay of a neutron extensively [14]. Note that this is a completely different situation. In that case the decay is the result of its interaction with a macrospace, overlapping the neutron accidentally; then no symmetry occurs as it happens in the hypothetical isolated proton decay above.

The origin of these ***three results*** in one movement (a more accurate description of the proton radius, a relation between $\hbar$ and *c* and a conversion factor 4 from mass to radiation) can be found in ***two details:*** The description of a spin particle at the surface of the proton, and Einsteins step from equations (19) and (20) to (21).

If these considerations are right, so if the description of the spin particle upon the surface of the proton reflects a physical reality, then equation (28) gives a basic reconciliation between phenomena at the smallest scale, represented by $\hbar$, and phenomena at the largest scale, represented by *c* , connected by the mass and the radius of a common particle, the proton, and a dimensionless translation factor 4.

5. CONCLUSIONS

A proton according to twin physics is generated by the interaction of two positively charged, coinciding H-units, being units of potential energy. Then an infinitesimally small magnetized particle called spin particle is also described, moving across the proton surface with almost the speed of light (less than 0,0001% difference), such that the energy of the spin particle is equal to the rest energy of the proton.

Inspired by the paper of Einstein in September 1905 [17], we compared the energy of this proton with a general radiation energy, expressed as Planck's constant times the turning frequency of its spin particle, because this is the only specific frequency of the proton. Then the proton energy is equal to exactly 4 times the radiation energy. This offers a relation between the reduced Planck's constant and the speed of light, in which only the radius and mass of the proton and the integer 4 occur (see equation (28)).

The integer 4 acts as a conversion factor from a mass-carrying particle to radiation, introducing the sense of movement in all directions and so revealing a potential free space around this mass. As an accidental side-effect, it predicts the radius of the proton to be $R_\sigma = 0.841235 \times 10^{-15}\ \mathrm{m}$ instead of the experimentally known value $R_\sigma = 0.84 \times 10^{-15}\ \mathrm{m}$. More research is needed to explore this conversion factor.

If this deduction reflects physical reality, then Planck's constant and the speed of light cannot be considered as independent constants of nature anymore. This is not really strange, as both are experimentally deduced from experiments with light; the only surprising thing is, that their relation contains the radius and the mass of a proton, and so it offers a link between phenomena at the smallest and the largest scale. The fact that this is obtained by using a complementary model confirms the importance of complementarity in physics.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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Biography of author(s)

Anna C. M. Backerra
Gualtherus Sylvanusstraat 2, 7412 DM Deventer, The Netherlands.

She had been graduated in theoretical physics at the Eindhoven University of Technology in The Netherlands and worked for three years at Philips Research Laboratories. She continued her research independently, making a search for complementary physics based upon the uncertainty relations of Heisenberg. At the time the general notion of complementarity was underdeveloped and could not be expressed in mathematical terms. To develop still complementary thinking, she studied composition at the Conservatory in Enschede (The Netherlands) and in Saint Petersburg (Russia). After graduating in music, she continued to compose for orchestra and chamber music in addition to physical research. She discovered that the histories of music and physics are highly analogous and used this to construct a complementary mathematical language, in which the principle of uncertainty is tackled from a mathematical perspective. Applying this language on physics she obtained 'twin physics', based on the concept that determinate and indeterminate aspects of a phenomenon are mutually independent and occur joined in nature. This offered a bridge between large- and small-scale phenomena, and so between quantum-mechanics and gravity. In 2010 her first publication about twin physics appeared, followed by eight papers considering various subjects by using this model. She succeeded in describing elementary particles as neutron, neutron decay, proton, electron, neutrino and Higgs particle, as well as gravitational waves. As an unexpected result she discovered four distinct types of electrons, elucidating features of nanomaterials. In 2018 she published a basic study-book about twin physics.