# The unification of elementary particles

Anna C. M. Backerra[a)]
*Gualtherus Sylvanusstraat 2, 7412 DM Deventer, The Netherlands*

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**Abstract:** Space is an intriguing part of reality, the potential of which in the past was underestimated. Einstein discovered a way to upgrade space to a source of mass, in which space and time occur united in a four-dimensional continuum. This was very successful on an astronomic scale, but gave no answers on an atomic scale. Previously, we developed a new mathematical tool to deal with uncertainty. Adapting this complementary language, and by considering three types of Heisenberg units as the basic elements of the universe, it is possible to show how their interaction generates particles out of time and space. In contrast to the standard model using quarks, the charge of a Heisenberg unit does not have to be split up: it is positive, negative, or neutral. To test the model, the attention is focused on the description of elementary particles. Our model is able to identify dark matter, three types of neutrinos, three types of electron-like particles, protons, and neutrons. As an example, a description is given of the stepwise generation of neutrinos. © *2012 Physics Essays Publication*. [DOI: 10.4006/0836-1398-25.4.601]

**Résumé:** L'espace est une composante intrigante de la réalité, dont le potentiel a été sous-estimé. Einstein a découvert une manière de requalifier l'espace comme source de masse, dans laquelle l'espace et le temps sont unifiés dans un continuum à quatre dimensions. Cette découverte, couronnée de succès à l'échelle astronomique, n'a toutefois apporté aucune réponse à l'échelle atomique. Précédemment nous avons construit un outil mathématique nouveau permettant de gérer l'incertitude. En adaptant ce langage complémentaire, et en considérant trois types d'unités de Heisenberg comme les éléments fondamentaux de l'univers, il est possible de démontrer comment leur interaction génère des particules à partir du temps et l'espace. A la différence du Modèle Standard utilisant les quarks la charge d'une unité de Heisenberg n'a pas du être scindée: elle est positive, négative ou neutre. Pour tester ce modèle l'attention est fixée sur la description des particules élémentaires. Notre modèle est en mesure d' identifier de la matière noire, des neutrinos en trois types, des particules du type électron de trois sortes, des protons et des neutrons. Une description est présentée de la génération échelonnée des neutrinos.

Key words: Unification Theory; Elementary Particles; Complementarity; Indeterminism; Quantum Mechanics; Dark Matter; Neutrino; Electron; Higgs Field.

## I. HISTORICAL BACKGROUND

Space is an intriguing part of reality, the potential of which has been underestimated in the past. From antiquity until the 18th century, the idea of empty space was considered as a conceptual impossibility. Space was only an abstraction to compare different arrangements of bodies, so in fact the ancient space did not exist at all. Christiaan Huygens hypothesized in the second half of the 17th century that space was filled with a substance called *ether*, to support light to propagate. Isaac Newton founded classical mechanics in 1687 based on the view that absolute space exists distinct from body, so space became viewed as an empty and passive part of reality. Because he failed to explain the behavior of light going through water (Foucault experiments), space was still considered as being filled with ether, penetrating all bodies. In 1887, Albert Michelson and Edward Morley tried to prove the existence of ether by measuring the difference in velocity of light moving parallel and perpendicular to the movement of the earth around the sun, but they found no difference, so the idea of ether was given up.

A completely new aspect of space was introduced by Michael Faraday in 1831. He discovered the relationship between electricity and magnetism and proposed that an electrically charged particle was surrounded by a field and so depicted the force exerted on other electrically charged objects. Space became associated with a field. His theories about induction allowed James Clerk Maxwell to determine his equations, published in 1865, describing how electric charges and currents act as sources for electric and magnetic fields. He discovered that light is a form of electromagnetic radiation, so space was associated with an active electromagnetic field. Max Planck figured out that the structure of light, radiating from a

[a)]annabackerra@gmail.com

 

black body, can be explained by introducing quanta, energetic units of emitted light, and he published this theory in 1900. This was the start of quantum mechanics, and it now seemed unnecessary to further investigate the properties of space. The quantum theory is the best-tested physical theory ever. The validity of its foundations is beyond any doubt, but it is difficult to conceive because the experiments are on an atomic scale.

Einstein accepted space as a vacuum being able to conduct light. In the beginning of the 20th century, he considered mass as a form of energy and a curvature of space around mass as the origin of gravity, so space became curved. This had an influence upon time and, as a consequence, he changed the classical notion of absolute time into relative time. Until the beginning of the 20th century, time was believed to be independent of motion, so this led to the name *relativity theory*. Because mass is related to gravity as well as to the curvature of space, mass can be identified with geometry, and space became a source of mass. The experimental results of this theory were, contrary to the results of Planck, on an astronomic scale, so were also difficult to conceive.

The gulf between scientific developments and our imagination became even greater following the results of the Davisson–Germer experiment in 1927: Electrons showed not only the usual behavior comparable with a tennis ball, but also a more spatial behavior, provoked by passing them through a crystal, by which ring patterns appeared upon a photographic layer.[1] This property had already been predicted by Louis de Broglie in 1924, who expressed this dual behavior in terms of particles and waves. Nobody could imagine what the effect of the crystal could be: The space between its atoms was, on a relative scale, so large that the electrons could not possibly be influenced by it. In fact, this was not a new problem, but the old space problem on an atomic scale: If the space between the crystal atoms is the only difference, it can only be this space that is interacting with the electrons. Unfortunately, at this time, thinking about space at an atomic level was out of favor. Also, traces of duality in daily life were not considered as being of any use in physics. However, in 1996, the author published an analogy between these quantum mechanical experiments and human behavior.[2]

Because in this new electron behavior, deterministic expectations were left aside, so Werner Heisenberg proposed in 1927 to incorporate a basic uncertainty in physics, counterparting determinism; this can be considered as the first step to relate space with uncertainty. Because of the lack of available mathematics to describe one electron in this way, Bohr introduced statistics, and due to the big success of this method in particle physics, the conviction grew that physics could not be grasped any more in another way than merely with scientific formulations. This can be considered as the end of imagination as a tool in physics. However, Heisenberg spent the remaining part of his life (1901–1976) searching for conceivable physical theories, resulting in a series of books of which *Schritte über Grenzen*[3] is the most profound.

In the course of the 20th century, a surprisingly large number of new elementary particles, popping up in vacuum, were experimentally discovered,[4] so the idea of space as the carrier of electromagnetic fields was extended to incorporate its potential to generate particles. A lot of new names were invented to describe them and, contrary to previous practice, they did not refer to experimental results. For instance the expression *charm* for the most massive of all quarks says nothing about its social skills.

In retrospect, the abolition in physics of the value of human potential to visualize or to relate new developments with known concepts, as a method to conceive new developments, seems to be the starting signal for the development of *fantasy physics*. Free inventions about the deeper structure of the physical world became more and more accepted in scientific discussions; it was as if man was defining the structure of the universe by himself. Physicists became acquainted with even more particles than can be isolated and with new theories, like the many-worlds interpretation and string theory, both based upon abstract ideas about the world.

Undoubtedly, all these visions reflect parts of the physical reality because they are invented by human beings living in a real world. Gradually, elementary particles seem not to be so very elementary anymore. At this moment, tens of particles are known, and we still lack unification. Moreover, a theoretical description of dark matter is lacking. A possible way out of this particle circus was provided by the suggestion of Max Jammer in 2000 that, for a unification of elementary particles, spacetime has to be considered as a source of mass in itself.[5] In this paper, we try to follow this suggestion, together with the demand of Heisenberg to rehabilitate imagination as a tool in physics, by using our newly developed complementary language[6] as the mathematical method and by requiring that each step in some way or another can be conceived by humans living in the real world.

## II. OUTLINE OF THE MODEL

In the previous paper,[6] we derived a mathematical method called *complementary language*, in which uncertainty is interpreted as an independent concept in nature. This was done by introducing the Heisenberg event as basic in nature. Later, it turned out that the linguistic use of the word *event* is not clear because this implies that there exists an interaction. For that reason, we change the name into *Heisenberg unit* (H-unit) and reserve the word *H-event* for an observable phenomenon, resulting from interacting H-units.

An H-unit is supplied with pairs of mathematical attributes, each containing a determined and an undetermined one; the complementarity of them is the basic principle. In this manner, the quantization of Planck and the uncertainty relations of Heisenberg are incorporated from scratch. The attributes exist in two types: Those of major and those of minor importance.

In applying this thinking to physics, three qualities to which attributes can belong are introduced: Time, space, and marking. Thus, each quality is described by a set of four attributes, which are complementary pairwise (two being of major and two of minor importance). Most striking in the description is the decision to consider space as an independent entity and not as a lack of matter. In this way, each H-unit is described by a set of 12 attributes. An H-unit can only be observed when interacting with another one, so it represents an elementary amount of potential energy, which by interaction with another H-unit is converted into an H-event. This way of dealing with phenomena is briefly called *twin physics*. The consideration of interactions between H-units seems to be suited for finding physical features of space, especially its ability to generate particles.

In the previous paper, we considered the attributes of space to be close to our normal human experience, but the attributes of time were constructed artificially by using complex figures. This was in conflict with the generally accepted view that time and space have to be considered in a similar way, but at that moment, there was not yet an alternative approach. Nevertheless, the results of this makeshift contrivance were encouraging enough to search for more realistic time attributes. In this paper, we construct time attributes strictly analogous to space attributes, leading to a complementary description of spacetime. In this way, we try to connect to ideas of combining space and time to one continuum, as proposed by Henri Poincaré, elaborated by Hermann Minkowski, and reformulated in the theory of special relativity in four dimensions by Albert Einstein in the beginning of the 20th century.

First, we repeat and adjust the previous mathematical basics of complementary language.[6] Then we derive new time attributes, as close as possible to daily life experience or at least conceivable in our imagination. By considering several cases of time and space, a description of dark matter, including neutrinos, is obtained. We try to find the answer to the question of how mass can be generated out of time and space. Then to be able to describe charged particles as well, we repeat and adjust the marking attributes. Several cases are considered, in which two more types of neutrinos appear, as well as protons, neutrons, and three different appearances of electrons.

## A. Complementary language

An *H-unit* is an elementary amount of potential energy, expressed in space and time, in complementary terms. We assume that each H-unit represents the same amount of potential energy. It can only manifest itself by interacting with one or more other H-units. The result of the interaction is an observable phenomenon, called an *H-event*; a characteristic part of an H-event is defined as a *quality*. We distinguish three qualities: Time, three-dimensional space, and marking. According to the Heisenberg uncertainty principle, each experimental result implies an amount of uncertainty. Therefore, for each quality, the H-unit $H_i$ possesses a set $h_i$ of mathematical *attributes* in two types: *Determinate* attributes, represented as $D_i$, and *indeterminate* ones, represented as $U^i$. The letter $U$ represents *uncertain* as one of the possible circumscriptions of indeterminism; indices of determinate attributes are written as subscripts and those of indeterminate attributes as superscripts of the symbol. An example of a determinate space attribute is one point; an example of an indeterminate one is a point, belonging to an infinite set of points, without additional information about which point it is exactly. The *interaction* of the two H-units is based upon the exchange of their attributes, such that the following two axioms are obeyed.

Axiom 1 says that the attributes of qualities contribute to any observation in pairs. A *joined pair* $x \bowtie y$ is defined as attributes $x$ and $y$ are necessarily observed together. Axiom 2 says that a joined pair of attributes contributes to the observation in such a way that one member is of major and the other of minor importance.

To provide the attributes with importance, the major ones are indicated in capitals and the minor ones in lowercase. Thus, a joined pair can be written as $X \bowtie y$. Then in general each quality of an H-unit with index $i$ can be described by the set $h_i$ of its four attributes:

$$h_i = \{D_i, U^i, d_i, u^i\}. \tag{1}$$

In joining attributes as pairs and subsequently linking joined pairs to form chains, we use the nomenclature of genetics. This is done not because of its conceptual background, but because the formal structure of complementary language has a strong analogy with the language used in genetics. This terminology helps to derive sets of observations which can quite easily be related to well-known experimental results. Although the list of definitions below might seem rather daunting at first glance, they soon will become clearer and more easily manageable in the subsequent text.

A *gene* $g$ is a joined pair of attributes, which are assigned importance. In general, with $P_i$ a major attribute of $H_i$ and $q_j$ a minor attribute of $H_j$, a gene can be written as

$$g = (P_i \bowtie q_j). \tag{2}$$

A *genetic set* $G$ is the collection of all genes belonging to one phenomenon. Considering only one H-unit, its *zero genetic set*, containing its two joined pairs, is

$$G_0 = \{g_1, g_2\} = \{(D \bowtie u), (U \bowtie d)\}. \tag{3}$$

The *link operator* is $\propto$, pronounced as "is linked to"; $g_i \propto g_j$ is defined as $g_i$ and $g_j$ occur combined in an observation. Obviously, if $g_i \propto g_j$, then $g_j \propto g_i$; if $g_i = g_j$, then $g_i \propto g_j$ is defined as $g_i$. Linking is not distributive over joining.

The parallel operator is $||$, pronounced as "is parallel to"; $g_i \,||\, g_j$ is defined as: $g_i$ and $g_j$ cannot occur combined in an observation. Obviously, if $g_i \,||\, g_j$, then $g_j \,||\, g_i$.

The *representation* of a mathematical object $X$ in a physical space is indicated by placing it between square brackets: $[X]$.

A *chromosome* $c$ is defined as a chain of linked genes, describing a specific property of the phenomenon. So if two genes are $g_i = P \bowtie q$ and $g_j = R \bowtie s$, then a first-order chromosome is

$$c_{ij} = g_i \propto g_j = (P \bowtie q) \propto (R \bowtie s). \tag{4}$$

The *set of chromosomes* $C$ contains all chromosomes of one phenomenon. There is in general a huge amount of possible genetic combinations, but not all of them are allowed. This originates in the impossibility to observe $D$ and $U$ of one H-unit on one and the same moment, in line with the first experiments in quantum mechanics, resulting in either wave or particle behavior, and reflected in the Heisenberg uncertainty relationships. This is expressed in the *exclusion principle for genes*: a gene containing a determinate major attribute of $H_i$ cannot link with a gene containing an indeterminate major attribute *of the same H-unit*. This can be written as

$$(D_i \bowtie x) \,||\, (U^i \bowtie y). \tag{5}$$

By reducing the influence of minor attributes $x$ and $y$ infinitely and assuming continuity, the exclusion principle can be written in short as

$$D_i \,||\, U^i. \tag{6}$$

The next step is the transformation from mathematical spaces to real observational spaces, like three-dimensional space and the time axis.

A *complementary observation* $\Omega_n$ is defined as the representation of a chromosome in a suitable observational space (in the previous paper, this was indicated by $\omega$). Thus, the complementary observation of a first-order chromosome is

$$\Omega_n(g_i \propto g_j) = [g_i \propto g_j] = [(P \bowtie q) \propto (R \bowtie s)], \tag{7}$$

and the *complementary set* $\Omega$ is defined as a set of $n$ complementary observations:

$$\Omega = \{\Omega_1, \Omega_2, \Omega_3, \ldots, \Omega_n\}. \tag{8}$$

A *classical observation* $O_n$ is defined as the limit of a complementary observation if the influence of the minor attributes is infinitely reduced; the *classical set* $O$ is the set of all classical observations:

$$O = \{O_1, O_2, O_3, \ldots, O_n\}. \tag{9}$$

A *zip* $Z_i$ is a set containing two elements: A classical observation and the corresponding complementary observation, so

$$Z_i = \{O_i, \Omega_i\}, \tag{10}$$

(in the previous paper, we called a zip an *appearance*, but it turned out that this was one step too fast).

A *zipper* contains all elements of $O$, combined with the corresponding elements of $\Omega$, so

$$Z = \{Z_1, Z_2, Z_3, \ldots, Z_n\}. \tag{11}$$

The zipper contains all possible classical observations, each combined with the corresponding complementary observation.

An *appearance* $A_i$ of zip $Z_i$ is an interpretation of its two simultaneously observed elements ($O_i$ and $\Omega_i$); this is notated as

$$Z_i \Rightarrow A_i. \tag{12}$$

The zip may lose some of its attributes as a consequence of the chosen interpretation, by which some aspects are neglected.

The *set of appearances* $A(Z)$ of a phenomenon, generated by two interacting H-units, is a set containing one interpretation of each zip, so in principle

$$A(Z) = \{A_1, A_2, \ldots, A_n\}. \tag{13}$$

Some appearances may be empty. When necessary, to obtain a natural time sequence, we will change the sequence of these elements.

This was the last step of our model from the concept of interacting H-units via mathematics and physics to human interpretation. To find the expressions to interpret, we first have to go back to the H-units and consider how the mixing of genes can occur.

The *interaction between two H-units* is obtained by considering two interacting H-units, $H_1$ and $H_2$, described by the sets of attributes $h_1$ and $h_2$, which are $\{D_1, U^1, d_1, u^1\}$ and $\{D_2, U^2, d_2, u^2\}$. This exchange is notated as $h_1 * h_2$. The interaction products are constituted out of zero genes and of genes with interchanged minor attributes; they are called the *first order-chromosomes*, having two genes. The first-order chromosomes are then again linked with each other to obtain *second-order chromosomes*, having four genes. By applying the exclusion principle, the number of possibilities reduces to only four, and chromosomes of higher order do not exist.

The obtained set of second-order chromosomes[6] is

$$C_2(h_1 * h_2) = \left\{ \begin{array}{l} (D_1 \bowtie u^1) \propto (D_2 \bowtie u^2) \propto (D_1 \bowtie u^2) \propto (D_2 \bowtie u^1) \\ (U^1 \bowtie d_1) \propto (U^2 \bowtie d_2) \propto (U^1 \bowtie d_2) \propto (U^2 \bowtie d_1) \\ (D_1 \bowtie u^1) \propto (U^2 \bowtie d_2) \propto (D_1 \bowtie d_2) \propto (U^2 \bowtie u^1) \\ (D_2 \bowtie u^2) \propto (U^1 \bowtie d_1) \propto (D_2 \bowtie d_1) \propto (U^1 \bowtie u^2) \end{array} \right\}. \tag{14}$$

Notice that the genes of the first two elements originate from single H-units, while the other two contain mixed genes. By representing the chromosomes in an observational space, we obtain the *complementary set*, containing four elements:

$$\Omega(h_1 * h_2) = \left\{ \begin{array}{l} [(D_1 \bowtie u^1) \propto (D_2 \bowtie u^2) \propto (D_1 \bowtie u^2) \propto (D_2 \bowtie u^1)] \\ [(U^1 \bowtie d_1) \propto (U^2 \bowtie d_2) \propto (U^1 \bowtie d_2) \propto (U^2 \bowtie d_1)] \\ [(D_1 \bowtie u^1) \propto (U^2 \bowtie d_2) \propto (D_1 \bowtie d_2) \propto (U^2 \bowtie u^1)] \\ [(D_2 \bowtie u^2) \propto (U^1 \bowtie d_1) \propto (D_2 \bowtie d_1) \propto (U^1 \bowtie u^2)] \end{array} \right\}. \tag{15}$$

The *classical set* is obtained by reducing the minor attributes to the limit:

$$O(h_1 * h_2) = \{[D_1 \propto D_2], [U^1 \propto U^2], [D_1 \propto U^2], [D_2 \propto U^1]\}. \tag{16}$$

The four possible zips of the phenomenon are collected in a set:

$$Z(\kappa_1) = \{Z_1, Z_2, Z_3, Z_4\} = \{\{O_1, \Omega_1\}, \{O_2, \Omega_2\}, \{O_3, \Omega_3\}, \{O_4, \Omega_4\}\}. \tag{17}$$

Thus, the zipper for two interacting H-units $H_i$:$\{D_i, U^i, d_i, u^i\}$ with $\{i, j\} = \{1, 2\}$ is a set of four elements:

$$Z(h_1 * h_2) = \left\{ \begin{array}{l} \{[D_1 \propto D_2], [(D_1 \bowtie u^1) \propto (D_2 \bowtie u^2) \\ \quad \propto (D_1 \bowtie u^2) \propto (D_2 \bowtie u^1)]\} \\ \{[U^1 \propto U^2], [(U^1 \bowtie d_1) \propto (U^2 \bowtie d_2) \\ \quad \propto (U^1 \bowtie d_2) \propto (U^2 \bowtie d_1)]\} \\ \{[D_1 \propto U^2], [(D_1 \bowtie u^1) \propto (U^2 \bowtie d_2) \\ \quad \propto (D_1 \bowtie d_2) \propto (U^2 \bowtie u^1)]\} \\ \{[D_2 \propto U^1], [(D_2 \bowtie u^2) \propto (U^1 \bowtie d_1) \\ \quad \propto (D_2 \bowtie d_1) \propto (U^1 \bowtie u^2)]\} \end{array} \right\}. \tag{18}$$

The zipper describes *four possible observations of a Heisenberg event*. In each of the four elements, the first part describes the classical observation and the second the complementary one. These parts appear simultaneously, so to interpret them, they have to be combined into one appearance $A_i$ of the H-event. Distinct appearances cannot be observed simultaneously, but they have to be compatible with each other because they represent different images of one and the same interaction.

## III. REPEATING AND ADJUSTING SPACE ATTRIBUTES

Space attributes are described in general for H-unit $H_i$. The *major determinate attribute*, describing ultimate contraction, is chosen as

$$D_i(\mathbf{x}) = P_i, \tag{19}$$

in which $P_i$ is a *major point of space* with zero extension. It is an expression of the notion *here*, like a single point upon a map of the world. To find a suitable *major indeterminate attribute* $U^i(\mathbf{x})$, describing ultimate expansion, we define $S^i$ as a finite sphere with central point $P_i$, having a radius $R$ chosen to be deliberately large but not infinite and with its border excluded. In the previous paper, $S^i$ was defined as an infinite space. This restriction to a finite extension is chosen in analogy with the description of time that will be introduced in Section IV. To use this space as an attribute, we have to exclude the central point and obtain the *major space* $S^i \backslash P_i$ as a suitable major indeterminate attribute, written as

$$U^i(\mathbf{x}) = S^i \backslash P_i. \tag{20}$$

This is an expression of the notion *not here*, which might be any other place in the universe, if the radius of $S^i$ is chosen to be sufficiently large. In this way, we have created two major attributes: Major point of space $P_i$ as the most determinate answer to the question "where does it happen", and major space $S^i \backslash P_i$ as the most indeterminate answer, implying not more than "somewhere in the major space, only not in the center". Together, they constitute the *major space system*, written as $(S^i \backslash P_i) \cup P_i$, which equals the total space $S^i$.

For the *minor indeterminate attribute* $u^i$, we have chosen the inner space of a sphere $s^i$, which is the set of points with an absolute distance less than $r$ to the point $P_i$ (with $r \ll R$), called a *minor space*. This space is less indeterminate than $S^i$ (more contracted); $P_i$ is included:

$$u^i(\mathbf{x}) = s^i. \tag{21}$$

This could be associated with the inner space of our body, which seems to be zero if we look upon the world map; only the shape is more complicated. The *minor determinate attribute* $d_i$ must be a less contracted and less exact observable object than the major point. *Less contracted* means that it must have a finite extensiveness; *less exact observable* means that the position of the minor point is not so strictly determined as that of the major one. Both requirements can be met by introducing a mathematical object called a *pellicle* $p_i$, spread out over the surface of $s^i$ like the skin of an apple such that the pellicle and minor space have no points in common and having a thickness $d\mathbf{r}$, which has an absolute value which is small compared with $r$ (in the previous paper, we defined its thickness as zero). Thus, the minor indeterminate attribute is

$$d_i(\mathbf{x}) = p_i. \tag{22}$$

The pellicle turns out to be a very practical device as a minor determinate attribute, as a counterpoint for the major determinate attribute: Major point $P$.

The two complementary attributes $s^i$ and $p_i$ constitute the *minor space system* $s^i \cup p_i$, which means that they exclude each other and together cover the space completely.

Summarizing the chosen attributes of space, we have: Major point of space, major space, pellicle, and minor space, written as

$$D_i(\mathbf{x}) = P_i, U^i(\mathbf{x}) = S^i \backslash P_i, d_i(\mathbf{x}) = p_i, u^i(\mathbf{x}) = s^i. \tag{23}$$

The set of space attributes $\mathrm{h}^{\mathrm{i}}$ belonging to one Heisenberg unit $\mathrm{H_i}$ can be written as [see Eq. (1)]

$$h_i(\mathbf{x}) = \{P_i, S^i \backslash P_i, p_i, s^i\}. \tag{24}$$

This collection of attributes has the common feature that, mathematically, they all can be considered as three-dimensional space intervals of four distinct types, depending on their relative size and the role of the border: $S^i \backslash P_i$ is the largest space interval, no border included; $s^i$ is a smaller space interval, the lower border (point $P$) included; $p_i$ is again a smaller space interval, both borders included; $P_i$ is the smallest space interval (zero width) in which the borders coincide. The zero genetic space set is, according to Eq. (3)

$$G_0(\mathbf{x}) = \left\{(P_i \bowtie s^i), (S^i \backslash P_i \bowtie p_i)\right\}. \tag{25}$$

*Joining* of space attributes is defined such that the joining of a major with a minor attribute equals the minor attribute, provided that they have at least one point in common. For major points of space, we define:

$$\begin{aligned} &P_i \bowtie s^j = s^j \quad \text{if } P_i \in s^j; \\ &P_i \bowtie s^j = \varnothing \quad \text{if } P_i \notin s^j; \\ &P_i \bowtie p_j = p_j \quad \text{if } P_i \in p_j; \\ &P_i \bowtie p_j = \varnothing \quad \text{if } P_i \notin p_j; \end{aligned} \tag{26}$$

and for major spaces:

$$\begin{aligned} &S^i \bowtie p_j = p_j \quad \text{if } p_j \subset S^i; \\ &S^i \bowtie p_j = \varnothing \quad \text{if } p_j \not\subset S^i; \\ &S^i \bowtie s^j = s^j \quad \text{if } s^j \subset S^i; \\ &S^i \bowtie s^j = \varnothing \quad \text{if } s^j \not\subset S^i. \end{aligned} \tag{27}$$

The effect of the joining operation is a focusing of our attention from major attributes to minor ones: Less contracted for $P_i$ and less indeterminate for $S^i$.

*Linking* of space genes, resulting from joining of attributes, is defined as taking their intersection, so $g_1 \propto g_2 = g_1 \cap g_2$.

The effect of the linking operation is to draw attention to the common parts of the geometric objects, which are described by the genes. This reflects the assumption that H-units are geometrically only observable as far as they are connected to another H-unit.

The *representation* of a mathematical space attribute (a mathematical object) in an observable space is this attribute in three-dimensional real space, so a geometrical object. For all space attributes, the representation is similar to the mathematical object, so if the mathematical object is, for instance, $s^1 \cap s^2$, then its representation in a real space is $[s^1 \cap s^2]$, being equal to $s^1 \cap s^2$.

The *classical and complementary space sets* of two interacting H-units $H_1$ and $H_2$ can be found by inserting the sets of attributes $h_1$ and $h_2$ into Eqs. (16) and (15). By representing them in an observable space and combining corresponding classical and complementary elements, we obtain the *space zipper* $Z(h_1 * h_2, \mathbf{x})$, generated by two interacting H-units $H_1$ and $H_2$ with sets of space attributes $h_1(\mathbf{x})$ and $h_2(\mathbf{x})$ as

$$Z(h_1 * h_2, \mathbf{x}) = \left\{ \begin{array}{l} \left\{P_1 \cap P_2, s^1 \cap s^2 \cap (P_1 \bowtie s^2) \cap (P_2 \bowtie s^1)\right\} \\ \left\{S \backslash \{P_1, P_2\}, p_1 \cap p_2\right\} \\ \left\{P_1 \cap (S^2 \backslash P_2), s^1 \cap p_2 \cap (P_1 \bowtie p_2)\right\} \\ \left\{P_2 \cap (S^1 \backslash P_1), s^2 \cap p_1 \cap (P_2 \bowtie p_1)\right\} \end{array} \right\}, \tag{28}$$

in which $S \backslash \{P_1, P_2\}$ is the abbreviation of $(S^1 \backslash P_1) \cap (S^1 \backslash P_1) \cap (S^2 \backslash P_2)$.

## A. Space cases

In the previous paper, we defined eight distinct space cases, and we assumed that the major spaces are comparable in magnitude. In this paper, we are specifically interested in appearances of particles as the result of interacting H-units. Hence, we need to concentrate on interactions in which both H-units move linearly in one and the same direction, but without any background, the movement of two H-units can only be defined with respect to each other, i.e. towards or away from each other. To be able to describe a joined movement, we introduce the *neutral H-unit* $H_0$, marked with a zero charge and consequently with zero vector fields. We assume that $H_0$ has a major space $S^0$ *which is at least one order of magnitude larger* than $S^i$ of a charged H-unit $H_i$. This seems reasonable as zero marking will save potential energy, which will be translated in a larger space. The attributes of $H_0$ are indicated by a zero, and in case the interaction of two neutral H-units is considered, we place additional indices at the free places (like $H_0^1$ and $H_0^2$).

If two charged H-units exist completely inside of $S^0$ and if none of them has common minor attributes with $H_0$ (so not touching the pellicle $p_0$ and not existing inside of $s^0$), then $S^0$ acts as a neutral background with $P_0$ as a point of reference. By this addition, we introduce the possibility to describe movements of the charged H-units (if using time attributes).

We define an extra *Space Case 9* as the interaction of one neutral (large) H-unit $H_0$ with one charged (small) H-unit $H_i$ existing completely in $S^0$ without sharing minor attributes. The associated space zipper is shown below, together with those of space cases 1 to 5. The symbol $\varnothing$ indicates an empty set.

Space Zipper 1: $P_1 = P_2$; $p_1 \cap p_2 = p$ (so identical geometries):

$$Z(\mathbf{x}) = \{\{P, s\}, \{S \backslash P, p\}, \varnothing, \varnothing\}. \tag{29}$$

Space Zipper 2: $r_1 = r_2 = r$ and $0 < P_{12} < r$, both major points inside the minor codomain:

$$Z(\mathbf{x}) = \left\{\left\{\varnothing, s^1 \cap s^2\right\}, \left\{S \backslash \{P_1, P_2\}, p_1 \cap p_2\right\}, \left\{P_1, \varnothing\right\}, \left\{P_2, \varnothing\right\}\right\}. \tag{30}$$

Space Zipper 3: $r < P_{12} < 2 \times r$, so both major points are outside the minor codomain and not on the pellicle:

$$Z(\mathbf{x}) = \{\varnothing, \{S \backslash \{P_1, P_2\}, p_1 \cap p_2\}, \{P_1, \varnothing\}, \{P_2, \varnothing\}\}. \tag{31}$$

Space Zipper 4: $r_1 = r_2 = r$ and $P_{12} = r$, so the major points are inside of each others pellicles:

$$Z(\mathbf{x}) = \left\{\varnothing, \{S \backslash \{P_1, P_2\}, p_1 \cap p_2\}, \left\{P_1, s^1 \cap p_2\right\}, \left\{P_2, s^2 \cap p_1\right\}\right\}. \tag{32}$$

Space Zipper 5, $P_{12} = 2 \times r$, so the pellicles touch each other:

$$Z(\mathbf{x}) = \{\varnothing, \{S\backslash\{P_1, P_2\}, p_1 \cap p_2\}, \{P_1, \varnothing\}, \{P_2, \varnothing\}\}. \quad (33)$$

Space Zipper 9: $S^i \subset S_0$; $s^i \cap s_0 = \varnothing$; $p_i \cap p^0 = \varnothing$, so $H_0$ covers $H_i$ without sharing minor attributes:

$$Z(\mathbf{x}) = \{\varnothing, S^i\backslash P_i, \varnothing, P_i\}. \quad (34)$$

In Space Zipper 9 the larger H-unit ($H_0$) is not represented at all, not even by a single attribute, and the smaller one ($H_i$) is only represented by its major attributes, without a complementary one. Thus, this interaction makes major point $P_i$ of $H_i$ observable in the center of its major space $S^i\backslash P_i$, without adding anything from $H_0$. Indeed $H_0$ acts as a neutral background.

## IV. NEW TIME ATTRIBUTES

As a first step, we consider the past. When we watch a photograph of our deceased grandmother, we know very well that we do not see her in the past; we see *in the present* a piece of paper or a screen with an image of her. In line with this, we assume that we can observe interacting H-units only now or at some later moment of their existence, so in general, we assume that *the past is not observable*. The exclusion of the past from our complementarity model of physical reality is in agreement with its starting point to consider only *interactions* of H-units as the basis of each phenomenon, which implies unceasing activity. The past is, on the contrary, unchangeable (unalterable), allowing no interaction of whatever kind anymore.

As a first time attribute, we have to choose the major deterministic attribute $D_i(t)$, analogous to the space attribute $D_i(\mathbf{x}) = P_i$, which is the major point of space, reflecting ultimate contraction. It is obvious to choose a point of time $T_i$ (with $T_i$ real) and call it the *major point of time*, so

$$D_i(t) = T_i. \quad (35)$$

The second time attribute to choose is the major indeterminate attribute $U^i(t)$, being analogous to the space attribute $U^i(\mathbf{x}) = S^i\backslash P_i$ in which $S^i$ is a deliberately large (but not infinite) spherical space with major point $P_i$ in its middle. This space attribute can be translated to a time attribute by defining it as a deliberately large interval of time (the upper border excluded), called the *full time* $F^i$. The first point of interval $F^i$ is $T_i$, and we suppose it has an endpoint $T_e$, large enough to stay out of reach during the time span we consider, so

$$F^i = \{t | T_i \le t < T_e\}. \quad (36)$$

This interval is not suited for $U^i(t)$ because it includes the major point of time [which is $D_i(t)$]. In the major space attribute, this was solved by excluding the central point, so we will do the same to get the corresponding time attribute. Thus, we choose $F^i\backslash T_i$ as the major indeterminate time attribute and call it the *future*:

$$U^i(t) = F^i\backslash T_i. \quad (37)$$

In doing so, two major attributes are created: Major point of time $T_i$ as the most determinate answer to the question "when did it happen in the major system?" and major future time $F^i\backslash T_i$ as the most indeterminate answer, saying not more than "at some later moment during their existence, but anyhow before the end of their lifetime". Together, they constitute the *major time system* of $H_i$, written as $(F^i\backslash T_i) \cup T_i$, which equals the full time $F^i$, in agreement with the previous assumption about the past. The H-unit is not observable at all points of time with $T < T^i$ because the major system does not contain them.

To find suitable minor time attributes, we first need a *minor time system* in which we have to define two minor attributes, such that one is indeterminate and the other determinate. Analogous to the minor indeterminate space attribute $s$ around $P$, we choose as the minor indeterminate time attribute $f^i$ small part of the future (up to $t_i$) and add $T_i$ to the set:

$$f^i = \{t | T_i \le t < t_i\}. \quad (38)$$

We call it the *flying time*, which will be elucidated later, so

$$u^i(t) = f^i. \quad (39)$$

In a similar way, the space pellicle $p$ around minor space $s$ with thickness $d\mathbf{r}$ can be translated to a one-dimensional time pellicle by choosing a small time interval with a length $dt_i$ at the upper border of the flying time $t_i$, so

$$\tau_i = \{t | t_i \le t < t_i + dt_i\}. \quad (40)$$

We call it the *minor point of time*, so

$$d_i(t) = \tau_i. \quad (41)$$

In this way, we have created two complementary time attributes $f^i$ and $\tau_i$ in the *minor time system* $f^i \cup \tau_i$; they exclude each other and cover the time interval starting at $T_i$ and reaching to $t_i + dt_i$ (borders included). Summarizing the attributes of time are

$$D_i(t) = T_i, U^i(t) = F^i\backslash T_i, d_i(t) = \tau_i, u^i(t) = f^i. \quad (42)$$

Thus, the set of time attributes $h_i(t)$ belonging to Heisenberg unit $H_i$ is [see Eq. (1)]

$$h_i(t) = \{T_i, F^i\backslash T_i, \tau_i, f^i\}, \quad (43)$$

and the zero genetic time set [see Eq. (3)] is

$$G_0(t) = \{(T_i \bowtie f^i), (F^i\backslash T_i \bowtie \tau_i)\}. \quad (44)$$

The set of time attributes $h_i(t)$ above is completely compatible with the three-dimensional space attributes:

$$h_i(\mathbf{x}) = \{P_i, S^i\backslash P_i, p_i, s^i\}, \quad (45)$$

which is the requirement we have set in the introduction. Thus, in complementary language, time and space can be expressed in similar attributes; the difference is only in the number of dimensions. Like the space attributes, the time attributes can be considered as four types of intervals, depending on their relative size and the role of the border: $F^i \backslash T_i$ (future) is the largest time interval with no border included; $f^i$ (flying time) is a smaller time interval, the lower border included; $\tau_i$ (minor point of time) is again a smaller time interval but with both borders included; $T_i$ (major point of time) is a zero time interval, in which the borders coincide.

We define joining of time attributes similar as joining of space attributes, which means that the result of joining equals the minor attribute, provided that there is at least one common element. The definitions concerning major attributes are completely compatible: They are obtained simply by inserting time instead of space attributes in Eq. (26):

$$\begin{aligned} T_i \bowtie f^j &= f^j \quad \text{if } T_i \in f^j; \\ T_i \bowtie f^j &= \varnothing \quad \text{if } T_i \notin f^j; \\ T_i \bowtie \tau_j &= \tau_j \quad \text{if } T_i \in \tau_j; \\ T_i \bowtie \tau_j &= \varnothing \quad \text{if } T_i \notin \tau_j; \end{aligned} \tag{46}$$

and in Eq. (27):

$$\begin{aligned} F^i \bowtie \tau_j &= \tau_j \quad \text{if } \tau_j \subset F^i; \\ F^i \bowtie \tau_j &= \varnothing \quad \text{if } \tau_j \not\subset F^i; \\ F^i \bowtie f^j &= f^j \quad \text{if } f^j \subset F^i; \\ F^i \bowtie f^j &= \varnothing \quad \text{if } f^j \not\subset F^i. \end{aligned} \tag{47}$$

The *linking* of genes, resulting from joining of attributes, is as with space attributes defined as taking the intersection of the constituting genes:

$$g_1 \propto g_2 = g_1 \cap g_2. \tag{48}$$

The *representation* of a time attribute in an observable space is the attribute itself, i.e. a point or an interval upon the time axis.

### A. Associations with time attributes

Before proceeding with joining time attributes to genes and linking genes to chromosomes to obtain the appearances of all possible time observations, we first search for associations of the chosen time attributes with our normal sense of time. The major attributes $T_i$ and $F^i \backslash T_i$ can easily be identified with *scientific present* and *scientific future*; the minor attributes $f^i$ and $\tau_i$ are less easy to interpret. If minor attribute $f^i$ (flying time, the interval from $T_i$ to $t_i$, including $T_i$) is part of an observation, it is impossible to hunt down the exact point of time of the event under consideration, and this has nothing to do with the quality of the measuring apparatus: It is the consequence of its definition, rooted in the Heisenberg uncertainty relationships. Although this could seem a nightmare for a scientist, it is daily experience for nonscientifically occupied human beings. It reflects the experience that time has already passed at the moment that one presses the stopwatch. This is not merely a feeling but a controllable feature of the human brain:[7] In normal situations, the brain gathers during about 3 s (with intervals of 20 to 40 ms) all incoming information *without distinguishing in time*. Only after that period, a decision is taken about the *present situation*, after which the brain starts again collecting information. For human beings, the upper border of the flying time (the minor point of time) is the first moment to decide whether the general situation of the past has changed. This means that human beings deal with time in steps, in line with the chosen minor time attributes, so *for individuals, the present is not a point but an interval.*

Thus, the *personal present* can be associated with the flying time plus the first point of the minor point of time, so with $f^i \cup t_i$; the upper border $t_i$ can be identified as the *clock time* which we measure when an athlete passes the finish. Then the *personal future* is the remaining part of the time axis, which is $F^i \backslash f^i \cup t_i$; its lower border $t_i + dt_i$ can be identified with the *variation of time*, related to his speed. Comparing the scientific division with this personal division in present and future, we notice that the personal one only appears by introducing minor time attributes. It is very encouraging that our complementarity model overcomes the incompatibility which seems to exist between scientific and personal notions of time.

Notice that a single H-unit does not generate observations; its time attributes are merely fixed numbers and intervals. Only if we introduce a second H-unit, interacting with the first, an H-event can be produced, so something can be observed. According to twin physics, *the running of time is a result of interaction between H-units*. Notice that, in that case, the major point of time $T_i$ (although moving over the time axis) stays the first point of the full time interval $F^i$.

### B. Interaction of time attributes

The next step is to insert time attributes of two H-units into the sets of time observations, to obtain time zippers. The classical time set of observations of two interacting H-units $H_1$ and $H_2$ can be found by inserting the sets of attributes $h_1$ and $h_2$ into Eq. (16), resulting in

$$O(h_1 * h_2, t) = \left\{ \begin{array}{l} T_1 \cap T_2 \\ (F^1 \backslash T_1) \cap (F^2 \backslash T_2) \\ T_1 \cap (F^2 \backslash T_2) \\ T_2 \cap (F^1 \backslash T_1) \end{array} \right\}. \tag{49}$$

Because we consider in all cases only two interacting H-units with sets of attributes $h_1$ and $h_2$, the indication $h_1 * h_2$ is suppressed in the following. For $T_2 \geq T_1$ (which we take as a convention), and assuming for convenience the end times of duration for both H-units equal, this reduces to

$$O(t) = \{T_1 \cap T_2, F^2 \backslash T_2, \varnothing, T_2 \cap (F^1 \backslash T_1)\}. \tag{50}$$

The empty third element is a striking difference with the classical space set; it is caused by the difference in the number of dimensions. In more detail, for $T_2 = T_1 = T$ is

$$O(t) = \{T, F^2 \backslash T_2, \varnothing, \varnothing\}, \tag{51}$$

and for $T_2 > T_1$ is

$$O(t) = \{\varnothing, F^2 \backslash T_2, \varnothing, T_2\}. \tag{52}$$

The complementary time set of observations is [see Eq. (15)]

$$\Omega(t) = \left\{\begin{array}{l} (T_1 \bowtie f^1) \cap (T_2 \bowtie f^2) \cap (T_1 \bowtie f^2) \cap (T_2 \bowtie f^1) \\ ((F^1\backslash T_1) \bowtie \tau_1) \cap ((F^2\backslash T_2) \bowtie \tau_2) \cap ((F^1\backslash T_1) \bowtie \tau_2) \\ \quad \cap ((F^2\backslash T_2) \bowtie \tau_1) \\ (T_1 \bowtie f^1) \cap ((F^2\backslash T_2) \bowtie \tau_2) \cap (T_1 \bowtie \tau_2) \\ \quad \cap ((F^2\backslash T_2) \bowtie f^1) \\ (T_2 \bowtie f^2) \cap ((F^1\backslash T_1) \bowtie \tau_1) \cap (T_2 \bowtie \tau_1) \\ \quad \cap ((F^1\backslash T_1) \bowtie f^2) \end{array}\right\}. \tag{53}$$

For $T_2 \geq T_1$ is in all cases $(F^1\backslash T_1) \bowtie f^2 = f^2$ and $(F^1\backslash T_1) \bowtie \tau_2 = \tau_2$; in the third element is $T_1 \bowtie \tau_2 = \varnothing$, which makes the total element empty, like in the classical set. If all joinings are carried out as far as possible and double genes are dropped, the set reduces to:

$$\Omega(h_1 * h_2, t) = \left\{\begin{array}{l} f^1 \cap f^2 \cap (T_1 \bowtie f^2) \cap (T_2 \bowtie f^1) \\ \tau_1 \cap \tau_2 \cap ((F^2\backslash T_2) \bowtie \tau_1) \\ \varnothing \\ f^2 \cap \tau_1 \cap (T_2 \bowtie \tau_1) \end{array}\right\}. \tag{54}$$

Corresponding classical and complementary elements can be combined to the time zipper.

The *time zipper* $Z(h_1 * h_2, t)$, generated by two interacting H-units $H_1$ and $H_2$ (for $T_2 \geq T_1$), having sets of time attributes $h_1(t)$ and $h_2(t)$ then is [see Eq. (18)]

$$Z(h_1 * h_2, t) = \left\{\begin{array}{l} \{T_1 \cap T_2, (f^1 \cap f^2 \cap (T_1 \bowtie f^2) \cap (T_2 \bowtie f^1))\} \\ \left\{F^2\backslash T_2, \left(\tau_1 \cap \tau_2 \cap \left((F^2\backslash T_2) \bowtie \tau_1\right)\right)\right\} \\ \{\varnothing, \varnothing\} \\ \left\{T_1 \cap (F^1\backslash T_1), \left(f^2 \cap \tau_1 \cap (T_2 \bowtie \tau_1)\right)\right\} \end{array}\right\}. \tag{55}$$

In the following, we drop empty elements, but maintain the element numbers. For $T_2 < T_1$, the fourth element is empty instead of the third. Later on, this reversed possibility appears to be interesting. In the previous paper, in which complementarity of time was achieved artificially by introducing complex numbers, we obtained only one time set for all geometric cases. With these new fully real time attributes, we have more possibilities. We can distinguish four time cases, dependent on the relative positions of the major points of time upon the time axis. We consider subsequently the case that $T_2$ is equal to $T_1$, is an element of $f^1$, is an element of $\tau_1$, and is an element of $F^1$.

## C. Time cases

Four cases can be distinguished for the time attributes of two H-units.

### 1. Major simultaneous

The major points of time are coinciding, so $T_2 = T_1 = T, f^2 = f^1 = f$, and $\tau_2 = \tau_1 = \tau$. The time zipper [see Eq. (55)] reduces to a set with two elements:

$$Z(t) = \{Z_1, Z_2\} = \left\{\{T, f\}, \{(F\backslash T), \tau\}\right\}. \tag{56}$$

This contains all attributes of one H-unit, so the interaction of two time-equal H-units makes the attributes observable without changing them. It is the only time case with a nonempty element $Z_1$, so the only one in which both flying times and major points of time occur.

### 2. Mixed simultaneous

Major point of time $T_2$ is an element of flying time $f^1$, so $T_2 \in f^1$, and the time zipper is

$$Z(t) = \{Z_2, Z_4\} = \left\{\begin{array}{l} \{F^2\backslash T_2, \tau_1 \cap \tau_2\} \\ \{T_2, \varnothing\} \end{array}\right\}. \tag{57}$$

### 3. Minor simultaneous

Major point of time $T_2$ is an element of minor point of time $\tau_1$, so $T_2 \in \tau_1$, and the time zipper is

$$Z(t) = \{Z_2, Z_4\} = \left\{\begin{array}{l} \{F^2\backslash T_2, \tau_1 \cap \tau_2\} \\ \{T_2, f^2 \cap \tau_1\} \end{array}\right\}. \tag{58}$$

If $T_2$ is equal to the left border of $\tau_1$ (so $T_2 = t_1$) then $f^2 \cap \tau_1 = \tau_1$ and $\Omega_4(t) = \tau_1$ (which is an interval containing $T_2$). However, if $T_2$ is at the right border (so $T_2 = t_1 + dt_1$) then $f^2 \cap \tau_1 = t_1 + dt_1 = T_2$, so $O_4$ and $\Omega_4$ are equal.

### 4. Not simultaneous

Major point of time $T_2$ is not coinciding with $T_1$, nor an element of $f^1$ or $\tau_1$, so $T_2 > t_1 + dt_1$. All complementary elements are empty; the time zipper is

$$Z(t) = \{Z_2, Z_4\} = \left\{\begin{array}{l} \{F^2\backslash T_2, \varnothing\} \\ \{T_2, \varnothing\} \end{array}\right\}, \tag{59}$$

so only classical observations appear: The major point of time and the future. Here, the minor attributes seem not to exist.

*To summarize,* we notice that all time zippers contain only two elements. Attributes $T_1$ and $F^1$ are not occurring at all; these major attributes of $H_1$ are only observable in cases where they coincide with those of $H_2$, and thus for convenience *we skip the index 2*, so we change $T_2$ into $T$ and consequently $F^2$ into $F$, remembering that still $T \geq T_1$. Then the time zippers can be written as

Time Case 1 $(T = T_1)$:

$$Z(t) = \{Z_1, Z_2\} = \left\{\{T, f\}, \{(F\backslash T), \tau\}\right\}, \tag{60}$$

Time Case 2 $(T \in f^1)$:

$$Z(t) = \{Z_2, Z_4\} = \{\{F\backslash T, \tau_1 \cap \tau_2\}, \{T, \varnothing\}\}, \tag{61}$$

Time Case 3 ($T \in \tau_1$):

$$Z(t) = \{Z_2, Z_4\} = \{\{F \backslash T, \tau_1 \cap \tau_2\}, \{T, f^2 \cap \tau_1\}\}, \tag{62}$$

Time Case 4 ($T > t_1 + dt_1$):

$$Z(t) = \{Z_2, Z_4\} = \{\{F \backslash T, \emptyset\}, \{T, \emptyset\}\}. \tag{63}$$

## V. COMBINING TIME AND SPACE ATTRIBUTES TO TIMESPACE ZIPPERS

In complementary language, time and space can be expressed in similar attributes, and the difference is only in the number of dimensions. Thus, we can combine them into a four-dimensional set of attributes. By combining space and time into a single continuum, a large number of theories are significantly simplified at both supergalactic and subatomic level. In general relativity theory, an event horizon is a boundary in spacetime beyond which events cannot affect an outside observer. Although an H-unit exists one level below observable phenomena, the attributes are chosen such that they are compatible with this: The radius of major space $S$ and the future $F$ are limited, so the H-unit cannot interact with another one if this exists completely outside of its $S$. However, the *sequence of space and time* has to be different from the present convention. If H-units are interacting, the attributes in general will intersect each other, so they might lose one or two dimensions. If we suppose that at least a one-dimensional space plus time is needed to describe an observation, then the time attributes must be considered first, followed by the three space dimensions, in agreement with the mathematical convention that the first dimension is the last to lose. To maintain the numbering of space coordinates traditionally indicated by the numbers 1, 2, and 3, we give the zero position to time attributes. As a consequence, four-dimensional space is not called spacetime, but *timespace*, and its basic four vector $X$ can be described as $X = (t, \mathbf{x})$. However, in the following, we continue to consider time and space attributes separately.

Then we can write the timespace zipper in general [see Eq. (17)] as

$$Z(t,\mathbf{x}) = \{Z_1, Z_2, Z_3, Z_4\} = \left\{ \begin{array}{l} \{\{O_1(t), O_1(\mathbf{x})\}, \{\Omega_1(t), \Omega_1(\mathbf{x})\}\} \\ \{\{O_2(t), O_2(\mathbf{x})\}, \{\Omega_2(t), \Omega_2(\mathbf{x})\}\} \\ \{\{O_3(t), O_3(\mathbf{x})\}, \{\Omega_3(t), \Omega_3(\mathbf{x})\}\} \\ \{\{O_4(t), O_4(\mathbf{x})\}, \{\Omega_4(t), \Omega_4(\mathbf{x})\}\} \end{array} \right\}. \tag{64}$$

For $T \geq T_1$ (the chosen convention) is $Z_3 = \emptyset$ in all time cases. However, in some space cases, we will consider also $T < T_1$; in these cases, $Z_3$ is nonempty and $Z_4 = \emptyset$.

We assume that *time is the first deciding quality* of an observation, so if a time element of a zip is not suited for the corresponding geometric object, the object cannot be observed. Moreover, we assume that, at one point of time (major or minor, respectively), only one point of space (major or minor, respectively) can be observed. If a time element is, for instance, one single point and the space element is a sphere, then only one single point of this sphere can be observed; the observation has to be reduced to this single point. The *reduction of a space attribute* is defined as the operation to remove a (part of a) subspace which cannot be observed in the available element of time. To portray this operation, the space elements are placed between broken brackets $\langle\ \rangle$. Inserting the general space zipper [see Eq. (28)] in Eq. (64) and adding this reduction, we obtain the general timespace zipper for $T \geq T_1$:

$$Z(t,\mathbf{x}) = \left\{ \begin{array}{l} \{O_1(t), \langle P_1 \cap P_2 \rangle\}, \\ \quad \{\Omega_1(t), \langle s^1 \cap s^2 \cap (P_1 \bowtie s^2) \cap (P_2 \bowtie s^1)\rangle\}\} \\ \{\{O_2(t), \langle S \backslash \{P_1, P_2\}\rangle\}, \{\Omega_2(t), \langle p_1 \cap p_2 \rangle\}\} \\ \{\{O_4(t), \langle P_2 \cap (S^1 \backslash P_1)\rangle\}, \\ \quad \{\Omega_4(t), \langle s^2 \cap p_1 \cap (P_2 \bowtie p_1)\rangle\}\} \end{array} \right\}. \tag{65}$$

The reduction of a minor space $\langle s \rangle$, observed during $f$, is simply $s$ because the attributes agree with each other: Both are minor indeterminate. This is written as

$$\{f, \langle s \rangle\} = \{f, s\}. \tag{66}$$

The reduction of a pellicle $\langle p \rangle$ is less simple because it is geometrically not a singular object. If the pellicle (a minor point of space) is observed during a small interval $\tau$ (a minor point of time), we assume that, although they correspond with each other, in this time interval only a part of the pellicle appears, called a *pellicle point* and written as $\pi(p)$, so

$$\{\tau, \langle p \rangle\} = \pi(p), \tag{67}$$

(in the previous paper, the pellicle point was indicated by $P_m$). Because we do not know its position in the pellicle exactly, the pellicle point has two unknown coordinates. Notice that a pellicle point in a two-dimensional space would have only one unknown angle; in a one-dimensional space, it would have no unknown angle at all, so its uncertainty would be expressed only by its extensiveness. The pellicle point in a three-dimensional space is conceived as a tiny sphere inside the pellicle, having an extensiveness as large as its width ($dr$) and touching both borders (at radius $r$ and at $r + dr$). A daily life object like that can be found in a bicycle: A ball in a ball bearing. Similarly, the reduction of a pellicle intersection, observed during $\tau_1 \cap \tau_2$, is a tiny sphere inside this circular intersection, written as

$$\{\tau_1 \cap \tau_2, \langle p_1 \cap p_2 \rangle\} = \pi(p_1 \cap p_2). \tag{68}$$

If the observation of a pellicle or an intersection of two pellicles is accompanied by an empty time element, then the observation is *independent of time*, so the geometric object does not have to be reduced. In that case, the complete pellicle or ring is observed.

## A. Mass

There is still no well-established theory revealing what "the nature of mass" is, explaining the origin, existence, and phenomenological properties of mass. While scientists happily discovered more and more elementary particles, this lack of understanding was expressed in 1971 by Heisenberg by asking the question: "[W]hy *these* elementary particle and why no others?"[3] The relativity theory of Einstein, with its well-known equation relating mass to energy, was already so popularized that, even in scientific circles, the idea was established that there is no difference between mass and energy. The conceptual vagueness of mass is shown in the historical overview of Max Jammer,[5] in which he thoroughly studies the difference between dynamics and kinematics, dealing with motions of bodies or particles, respectively, with and without regard to the causes of these motions. His conclusion is "[that we need] to define the mass of a body or particle on its own in purely kinematic terms and without any implicit reference to a unit of mass," and, "Such a definition, if it existed, would integrate dynamics into kinematics and eliminate the dimension of mass in terms of the other two fundamental dimensions of mechanics, length and time." The problem seems to him, generally speaking, to be in the use of the notion of force, "a procedure, as we have seen, is apt to involve a logic circle." Twin physics, using complementary language and H-units without the necessity to introduce forces, possibly offers new points of contact with these convictions.

To construct a complementary definition of mass, we first consider timespace attributes and notice that mass is associated with a *finite extensiveness*, so classical attributes (being infinite large or having no extensiveness at all) are not useful. Only minor timespace objects can be the carriers of mass. These objects are only observable if they appear as the result of an interaction and to the extent that they have an overlapping region. Thus, *mass is defined as the appearance of a four-dimensional minor timespace object*. With this definition, satisfying the assignments above, we can consider particles as being Heisenberg events and divide them into four types: If the appearing geometric object is the intersection of two minor spaces, the H-event is called a *major particle* $\sigma$; if it belongs to the intersection of two pellicles, the H-event is called a *minor particle* $\pi$; if it is the intersection of a minor space and a pellicle, like $s^i \cap p_j$, which has the shape of a thin dot upon a sphere, the H-event is called a *dot particle* $\delta$. As a borderline case, if a massless single point of space $P$ appears, the H-event is called a *point particle* $\Pi$. Notice that a minor particle is less contracted than a point particle, and because it has two unknown angular coordinates in the pellicle, it is less localized. These geometric features are not enough for a particle to exist. The attribute of time decides if a minor geometric object indeed appears as a mass. Thus, the particle has to be indicated by its geometric shape *together* with the moment or interval of time. It would be extremely correct to use the expression "timespace particle" instead of "particle", but for convenience, we stick to the traditional expression, so a major particle is, in principle, written as $\sigma(f, s)$, a minor particle as $\pi(\tau, p)$, a dot particle as $\delta(f^i \cap \tau_j, s^i \cap p_j)$, and a point particle as $\Pi(T, P)$. If in the following the charge and velocity are also added between these brackets, then the total description will be called the *passport* of the particle. However, in short, they might be indicated for convenience with only their geometric feature, like $\sigma_s$, $\pi_p$, $\delta_{s^i \cap p_j}$, or $\Pi_P$. Examining the general timespace zipper Eq. (65), it is clear that major particles originate from the complementary part of $Z_1$, which is $\{\Omega_1(t), \langle s^1 \cap s^2 \cap (P_1 \bowtie s^2) \cap (P_2 \bowtie s^1)\rangle\}$, and minor particles from the complementary part of $Z_2$, which is $\{\Omega_2(t), \langle p_1 \cap p_2\rangle\}$. Dot particles originate from the complementary part of $Z_4$, which is $\{\Omega_4(t), \langle s^2 \cap p_1 \cap (P_2 \bowtie p_1)\rangle\}$, and point particles from the classical parts of $Z_1$ and $Z_4$, which are $\{O_1(t), \langle P_1 \cap P_2\rangle$ and $\{O_4(t), \langle P_2 \cap (S^1 \backslash P_1)\rangle\}$.

## B. Dark matter

If mass is produced by interacting neutral H-units, it is dark matter, due to the lack of marking. All space cases (except Space Case 9) can be considered for *two interacting neutral H-units* $H_0^1$ and $H_0^2$. We must be aware of the fact that they have no background as a reference for their movement, so they can only move towards or away from each other. Only major and minor particles carry mass, not point particles, so only $Z_1$ and $Z_2$ are important. Then Time Cases 2 and 3 [see Eqs. (61) and (62)] give the same results, and Time Case 4 is not interesting. First, we will consider Time Case 1 [see Eq. (60)], and it will subsequently be combined with Space Cases 1, 2, 4, and 3 (numbering of the previous paper), with static geometric positions. In this sequence, the overlapping region of the minor spaces is decreasing step by step until they have no minor contact any more. After that (in Subsection C), we consider them successively to simulate a movement of the H-units away from each other. Then for *Space Zipper 1* (identical geometries), the timespace zipper is

$$Z(t, \mathbf{x}) = \{Z_1, Z_2\} = \left\{ \begin{array}{l} \{\{T, P_0\}, \{f, s^0\}\} \\ \{\{F \backslash T, S^0 \backslash P_0\}, \{\tau, \pi(p_0)\}\} \end{array} \right\}. \tag{69}$$

Notice that the classical observation $\{F\backslash T, S^0\backslash P_0\}$ is only facilitating the complementary one $\{\tau, \pi(p_0)\}$, without adding anything special, so in the set of appearances it does not occur explicitly:

$$A(t, \mathbf{x}) = \{\{\Pi(T, P_0), \sigma(f, s^0)\}, \pi(\tau, p_0)\}. \tag{70}$$

The first element is a major particle $\sigma_{s^0}$, with point particle $\Pi_{P_0}$ in its center; the second is a minor particle $\pi_{p_0}$ occurring in the pellicle. Because the particles occur in one and the same timespace case, the two observations must be compatible, so the minor particle has to exist at the surface of the major one. We identify the major one with a *spherical dark particle* and the minor with a spherical *minor dark particle*, glued to its surface. These particles are considered as H-events, produced by the two interacting neutral H-units; the minor particle might be identified with a *gluon*. The time attributes $f$ and $\tau$ are not coinciding, so the particles cannot be observed simultaneously.

For Space Zipper 2 (both major points exist in the minor codomain) the timespace zipper is

$$Z(t,\mathbf{x}) = \{Z_1, Z_2\} = \left\{ \begin{array}{l} \{\{T,\varnothing\}, \{f, s_1^0 \cap s_2^0\}\} \\ \{\{F\backslash T, \langle S^0 \backslash \{P_0^1, P_0^2\}\rangle\}, \{\tau, \pi(p_0^1 \cap p_0^2)\}\} \end{array} \right\}, \tag{71}$$

so the set of appearances is

$$A(t,\mathbf{x}) = \{\{\sigma(f, s_1^0 \cap s_2^0)\}, \pi(\tau, p_0^1 \cap p_0^2)\}. \tag{72}$$

The first element is a particle in the shape of intersecting spheres (having noncoinciding center points), which we call an *oval dark particle*; the second element is again a spherical *minor dark particle*, existing glued to its surface, so again, two H-events are produced.

For *Space Cases 4 and 3* (no major points in the minor codomain) the zipper has only one element:

$$Z(t,\mathbf{x}) = Z_2(t,\mathbf{x}) = \{\{F\backslash T, S^0 \backslash \{P_0^1, P_0^2\}\}, \{\tau, \pi(p_0^1 \cap p_0^2)\}\}, \tag{73}$$

so no major particle appears; the appearance is

$$A = \{A_2\} = \pi(\tau, p_0^1 \cap p_0^2). \tag{74}$$

This is the minor particle which existed in the previous cases glued to the surface of the major particle. Because in this case no major mass appears, the minor particle exists independently, without restriction to the radius of the pellicle through which it travels and without a relationship with another particle. The circular pellicle intersection can be considered as a curved space through which it travels.

We identify this with a *neutrino*. In the Space Cases 3 and 4, the two neutral H-units produce only this H-event. In the next section, we will examine it more closely.

### C. Neutrinos

We consider the space cases above in succession, starting with coinciding H-units (Space Case 1), producing a spherical dark particle with a minor dark particle glued to its surface. As the H-units move away from each other, the pellicles shift (Space Case 2), so the minor codomain $s_1^0 \cap s_2^0$ shrinks, the dark major particle loses mass and changes from spherical to oval. According to conservation of energy laws, the gluon has to compensate this loss of energy by accelerating, and because its position is restricted to the ring-shaped pellicle intersection, it starts to *turn around* in one of the two possible directions. If the H-units continue to move away from each other, the major particle loses more and more mass, so the gluon travels faster and faster through the ring at the surface of the major particle to compensate this loss of energy. Ultimately, there will be a moment that the two major points leave the minor codomain because they reach each others' pellicle (Space Case 4); then the dark major particle is *annihilated*. By increasing their distance, the H-units reach Space Case 3 (without more change with respect to mass).

The minor particle $\pi(\tau, p_0^1 \cap p_0^2)$, existing in the ring-shaped pellicle intersection, has to compensate the rest mass of the dark major particle as soon as this is annihilated, which is possible by increasing its velocity during the collapse. We will write this velocity $\mathbf{v}_\pi$ in the passport as $\pi(\tau, p_0^1 \cap p_0^2, \mathbf{v}_\pi)$. From that moment, the pellicle radii are not restricted to the circumference of the major particle anymore, and we expect them to expand considerably. If this happens, then the minor particle, which existed before the annihilation upon the surface of the dark major particle, is shot away over a circular track with a presumably much larger radius. It might be considered as traveling through a curved space. It carries the energy of the rest mass of the dark major particle together with its own rest mass. Thus, it has a constant velocity. We identify it with a *neutrino*. The motion along the pellicle intersection can be realized in two different directions, which can be identified with its *spin*. To summarize, the neutrino is created as the spin-off of an annihilating larger particle, and it has a constant velocity, depending on the rest mass of the annihilated particle. This is in agreement with the experimental facts that neutrinos can be created in radioactive decay processes. The loss of its relationship with the major particle is reflected in its possibility to travel great distances through matter.

If a major particle $\sigma$ has radius $r$, rest mass $m_\sigma$, and a velocity much smaller than the velocity of light, and if the velocity of the neutrino after the decay is $v$, then to compensate the loss of $m_\sigma$, this must be such that

$$m_\sigma \times c^2 = m_\pi \times c^2 \times \left(1 - \frac{v^2}{c^2}\right)^{-1/2}. \tag{75}$$

If we write the radius of a minor particle $\pi$ as $x \times r$ (with $0 < x \leq r/2$), then the rest mass $m_\pi$ of $\pi$ can be written as $m_\pi = x^3 \times m_\sigma$. Inserting this and simplifying the equation, we obtain

$$1 = x^3 \times \left(1 - \frac{v^2}{c^2}\right)^{-1/2}, \tag{76}$$

so

$$v = c \times (1 - x^6)^{1/2}, \tag{77}$$

which means that $0,99 \times c < v < c$. Thus, the velocity of a neutrino is close to the velocity of light, but not exceeding it.

## VI. REPEATING AND ADJUSTING MARKING ATTRIBUTES

When using the marking set according to the previous paper, it became clear that, for some cases, the linking of attributes was carried out too early, which caused information to disappear. This, together with a few other subsequently identified mistakes which have been corrected here and the addition of a new principle for the magnetic field, justifies our new derivation of the marking zipper given below.

Marking of the attributes of H-units, being mathematical objects of time and space, is in complementary language possible by using vector fields. For the determinate vector field, we have chosen an infinite, real, $n$-dimensional, radially oriented, time-dependent vector field $\mathbf{E}(t)$, having a source of strength $Q$ at a point $P$; in $P$, the zero vector $\mathbf{o}$ is defined. This is called the *electric field.* A vector of $\mathbf{E}(t)$, indicated by $\mathbf{e}(t)$, is called *positive* if it points from $P$ to infinity. Applying the divergence theorem of the first law of Gauss yields the requirement $\nabla \cdot \mathbf{E}(t) = Q$.

For the indeterminate vector field, we have chosen an infinite, real, $n$-dimensional, circularly oriented, time-dependent vector field $\mathbf{B}(t)$ with central point $P$; in $P$, the zero vector $\mathbf{o}$ is defined. This is called the *magnetic field.* A vector of $\mathbf{B}(t)$, indicated by $\mathbf{b}(t)$, has a direction tangent to a spherical surface, but even adjacent vectors may point in all directions, and there is no information about their absolute value. Nevertheless, by definition, there is only one vector in each point. With this definition, the marking fields are in each point perpendicular to each other, so $\mathbf{E}(t) \cdot \mathbf{B}(t) = \mathbf{O}$, and because $\mathbf{E}(t)$ is radial, $\nabla \cdot \mathbf{B}(t) = 0$. In $P$, the vector fields are both defined as the zero vector, so we need a distinguishing extra mark. In order to mark $P$ in a determinate way, the real number $Q$ is attached to it. To mark this point in an indeterminate way, the imaginary number $Q \times i$ (with $i = \sqrt{-1}$) is attached to it.

To be sure that the marking is effective, we add to the definition of $\mathbf{B}(t)$ the *principle of uniqueness*, which says that for any two H-units $H_i$ and $H_j$ (with $i \neq j$) the major marking attributes $\mathbf{B}^i(t)$ and $\mathbf{B}^j(t)$ are distinct from each other, so $\mathbf{B}^i(t) \neq \mathbf{B}^j(t)$. This infinite diversity can be supplied because $\mathbf{B}$ has, by definition, an infinite number of possible orientations, so even if two H-units have identical geometric and time attributes, their marking attributes are still distinct.

The minor attributes may be chosen in an arbitrary way, as long as they are complementary and excluding each other. Because we want them to produce genes with a vectorial character in time and space, two operators were chosen, one being timelike and the other one geometrical: $u = \partial/\partial t$ and $d = (\partial/\partial x, \partial/\partial y, \partial/\partial z) = \nabla$. By indicating the quality *marking* by $q$ (instead of the previous indication $\kappa_2$), the four marking attributes of H-unit $H_i$ then are

$$D_i(q) = \{Q_i, \mathbf{E}_i(t)\},$$
$$U^i(q) = \{Q_i \times i, \mathbf{B}^i(t)\},$$
$$d_i(q) = \nabla$$

and

$$\mathrm{u}^i(q) = \partial/\partial t, \tag{78}$$

on the conditions

$$\nabla \cdot \mathbf{E}_i(t) = Q_i \quad \text{and} \quad \nabla \cdot \mathbf{B}^i(t) = 0. \tag{79}$$

With this choice, suppressing the time dependency of the fields, the *set of marking attributes $h_i(q)$ belonging to Heisenberg unit $H_i$* is [see Eq. (1)]

$$h_i(q) = \{\{Q_i, \mathbf{E}_i\}, \{Q_i \times i, \mathbf{B}^i\}, \nabla, \partial/\partial t\}, \tag{80}$$

and the zero genetic marking set is

$$G_0(q) = \{\partial \mathbf{E}_i/\partial t, \nabla \times \mathbf{B}^i\}. \tag{81}$$

*Linking* of marking numbers is defined as addition and linking of vector fields as vector addition. To obtain the sets of observation, we insert the marking attributes in Eqs. (19) and (18), assuming $\partial/\partial t_i = \partial/\partial t_j = \partial/\partial t$ and $\nabla_i = \nabla_j = \nabla$. Then the *classical marking set* of $H_1$ interacting with $H_2$ is (note: in the previous paper, the links in the first element were carried out too early)

$$O(q) = \left\{ \begin{array}{l} [\{Q_1 \propto Q_2, \mathbf{E}_1 \propto \mathbf{E}_2\}] \\ [\{Q_1 \times i \propto Q_2 \times i, \mathbf{B}^1 \propto \mathbf{B}^2\}] \\ [\{Q_1, \mathbf{E}_1\}] \\ [\{Q_2, \mathbf{E}_2\}] \end{array} \right\}, \tag{82}$$

and the complementary marking set is

$$\Omega(q) = \left\{ \begin{array}{l} [\partial \mathbf{E}_1/\partial t \propto \partial \mathbf{E}_2/\partial t] \\ [\nabla \times \mathbf{B}^1 \propto \nabla \times \mathbf{B}^2] \\ [\partial \mathbf{E}_1/\partial t \propto \nabla \times \mathbf{B}^2 \propto \nabla \times \mathbf{E}_1 \propto \partial \mathbf{B}^2/\partial t] \\ [\partial \mathbf{E}_2/\partial t \propto \nabla \times \mathbf{B}^1 \propto \nabla \times \mathbf{E}_2 \propto \partial \mathbf{B}^1/\partial t] \end{array} \right\}. \tag{83}$$

In the previous paper,[6] it was shown that the second element of $O(q)$ reduces to zero by the requirement that, for identically marked H-units, the sets will reduce to that of a noninteracting H-unit. This holds under the conditions that $\partial \mathbf{E}_i/\partial t = \nabla \times \mathbf{B}^i$ and $\partial \mathbf{B}^i/\partial t = -\nabla \times \mathbf{E}_i$. Moreover, the indeterminate vector field $\mathbf{B}$ must be such that $[\mathbf{B}] = \mathbf{O}$, so it is not observable without joining with a minor marking attribute. Thus, $O_2(q) = \{0, \mathbf{O}\}$, which will be notated as an empty set, and the *general marking zipper* $Z(q)$, generated by two interacting H-units $H_1$ and $H_2$, having sets of time attributes $h_1(q)$ and $h_2(q)$, is

$$Z(q) = \left\{ \begin{array}{l} \{\{Q_1 \propto Q_2, \mathbf{E}_1 \propto \mathbf{E}_2\}, \partial \mathbf{E}_1/\partial t \propto \partial \mathbf{E}_2/\partial t\} \\ \{\varnothing, \nabla \times \mathbf{B}^1 \propto \nabla \times \mathbf{B}^2\} \\ \{\{Q_1, \mathbf{E}_1\}, \partial \mathbf{E}_1/\partial t \propto \nabla \times \mathbf{B}^2 \propto \nabla \times \mathbf{E}_1 \propto \partial \mathbf{B}^2/\partial t\} \\ \{\{Q_2, \mathbf{E}_2\}, \partial \mathbf{E}_2/\partial t \propto \nabla \times \mathbf{B}^1 \propto \nabla \times \mathbf{E}_2 \propto \partial \mathbf{B}^1/\partial t\} \end{array} \right\}, \tag{84}$$

on the conditions

$$\begin{aligned} &\nabla \cdot \mathbf{E}_i = Q_i; \\ &\nabla \cdot \mathbf{B}^i = 0; \\ &\partial \mathbf{E}_i/\partial t = \nabla \times \mathbf{B}^i; \\ &\partial \mathbf{B}^i/\partial t = -\nabla \times \mathbf{E}_i. \end{aligned} \tag{85}$$

These four conditions can be recognized as the laws of Maxwell. Keep in mind that, in $Z_1$, for equal charges, the operation *linking* produces *not* their addition: For $Q_1$

$= Q_2$ is $Q_1 \propto Q_2 = Q \propto Q = Q$. Moreover, two H-units having the same charges but different major points, do *not* have identical $\mathbf{E}$ fields.

The three sets of attributes $h_i(t)$, $h_i(\mathbf{x})$, and $h_i(q)$ [see Eqs. (43), (24), and (80)], each containing four attributes, are now combined to the *set of marked spacetime attributes* $h_i(t, \mathbf{x}, q)$, belonging to one Heisenberg unit $H_i$:

$$h_i(t,\mathbf{x},q) = \left\{D_i(t,\mathbf{x},q), U^i(t,\mathbf{x},q), d_i(t,\mathbf{x},q), u^i(t,\mathbf{x},q)\right\}, \tag{86}$$

resulting in

$$h_i(t,\mathbf{x},q) = \left\{\begin{array}{l}\{T_i, P_i, \{Q_i, \mathbf{E}_i\}\} \\ \{F^i\backslash T_i, S^i\backslash P_i, \{Q_i \times i, \mathbf{B}^i\}\} \\ \{\tau_i, p_i, \nabla\} \\ \{f^i, s^i, \partial/\partial t\}\end{array}\right\}. \tag{87}$$

The *general marked timespace zipper*, which is $Z(h_1(t, \mathbf{x}, q) * h_2(t, \mathbf{x}, q))$, can be obtained by inserting all attributes of $h_1(t, \mathbf{x}, q)$ and $h_2(t, \mathbf{x}, q)$ in Eq. (18). However, in the cases considered, this set will reduce drastically.

For the *neutral H-unit* $H_0$, marked by zero charges and no fields, each of the major marking attributes $\{Q_i, \mathbf{E}_i\}$ and $\{Q_i \times I, \mathbf{B}^i\}$ are replaced by $\{0, \mathbf{O}\}$ and the minor marking attributes $\nabla$ and $\partial/\partial t$ by the empty set $\varnothing$.

### A. Simplification of field terms for linear-moving, charged H-units

If we consider two linear-moving H-units, then we can simplify the marking zipper. If major point of space $P_i$ moves linearly, then $\partial\mathbf{E}_i/\partial t$ is a constant vector field which for positive $Q$ can be expressed by the $\partial\mathbf{E}_i/\partial t = \mathbf{M}_i$ and for negative $Q$ as $\partial\mathbf{E}_i/\partial t = -\mathbf{M}_i$ (with $\mathbf{M}_i$ a constant vector field). This means that in a link for equal charges is $\mathbf{M}_1 \propto \mathbf{M}_2 = \mathbf{M}_1 + \mathbf{M}_2$ and for opposite charges (with $Q_2 = -Q_1$ and $Q_1 > 0$) is $\mathbf{M}_1 \propto \mathbf{M}_2 = \mathbf{M}_1 - \mathbf{M}_2$. Because also $\partial\mathbf{E}_i/\partial t \propto \nabla \times \mathbf{B}^i$, we call $\mathbf{M}_i$ the *magnetic momentum field*. Momentum is not the same as velocity, but it is related to it in that the larger the mass is to which the momentum is attached, the lower the velocity will be. For that reason, we define the reduction of $\mathbf{M}_i$ as the velocity of the belonging particle; if this particle is called $\Theta$ and its velocity is $\mathbf{v}(\Theta)$, we can write the reduction as

$$\langle \mathbf{M}_1 \propto \mathbf{M}_2 \rangle \Rightarrow \mathbf{v}(\Theta). \tag{88}$$

The magnetic momentum field is *only useful if a geometric object is described* in the zip because only in that case can a particle appear. The larger this object is, the more mass we expect, and the smaller its velocity will be; for infinite large objects, the velocity is zero. Thus, if in $\Omega_1$ a geometric object is observed, the corresponding field term in Eq. (83) can be written as

$$\partial\mathbf{E}_1/\partial t \propto \partial\mathbf{E}_2/\partial t = \mathbf{M}_1 \propto \mathbf{M}_2, \tag{89}$$

and in $\Omega_2$ the corresponding field term in Eq. (83) can be written as $\partial\mathbf{E}_1/\partial t \propto \partial\mathbf{E}_2/\partial t$, so

$$\nabla \times \mathbf{B}^1 \propto \nabla \times \mathbf{B}^2 = \mathbf{M}_1 \propto \mathbf{M}_2. \tag{90}$$

Similarly, if a geometric object is described in $\Omega_3$, the corresponding field term in Eq. (83) can be written as $\partial\mathbf{E}_1/\partial t \propto \partial\mathbf{E}_2/\partial t \propto -\partial\mathbf{B}^1/\partial t \propto \partial\mathbf{B}^2/\partial t$, so as $\mathbf{M}_1 \propto \mathbf{M}_2 \propto -\partial\mathbf{B}^1/\partial t \propto \partial\mathbf{B}^2/\partial t$. Because of $\mathbf{E}_i \cdot \mathbf{B}^i = \mathbf{O}$ and $\mathbf{B}^i \neq \mathbf{B}^j$, two links can be carried out by vector addition, and the field term can be written as

$$\Omega_3(q) = \mathbf{M}_1 \propto \mathbf{M}_2 - \partial\mathbf{B}^1/\partial t + \partial\mathbf{B}^2/\partial t. \tag{91}$$

In a similar way, the field term in $\Omega_4$ can be written as

$$\Omega_4(q) = \mathbf{M}_1 \propto \mathbf{M}_2 + \partial\mathbf{B}^1/\partial t - \partial\mathbf{B}^2/\partial t. \tag{92}$$

### B. The neutral H-unit as a background for charged H-units

Interacting charged H-units cannot generate stable mass with a nonzero velocity because, instead of moving together in one direction, their major points of space can only move towards or away from each other. By introducing an extra neutral H-unit ($H_0$), this problem can be solved: Its major point acts as a geometric reference for the charged H-units. If we consider only charged H-units existing in the major space of $H_0$ *without having minor attributes in common*, we expect the influence of $H_0$ upon a single charged H-unit to be zero or negligible. To examine this influence, we consider the marking zipper of the interaction between $H_0$ and $H_i$ having charge $Q_i$, under the conditions $S^0 \cap S^i = S^i$, which are met if $s^0 \cap S^i = \varnothing$ and $p_0 \cap S^i = \varnothing$. If we take $H_0$ as the first, this is according to Eq. (84)

$$Z(q) = \left\{\begin{array}{l}\{\{Q_i, \mathbf{E}_i\}, \partial\mathbf{E}_i/\partial t\} \\ \{\varnothing, \nabla \times \mathbf{B}^i\} \\ \{\varnothing, \{\nabla \times \mathbf{B}^i \propto \partial\mathbf{B}^i/\partial t\}\} \\ \{\{Q_i, \mathbf{E}_i\}, \{\partial\mathbf{E}_i/\partial t \propto \nabla \times \mathbf{E}_i\}\}\end{array}\right\}. \tag{93}$$

Combining this with the general space zipper [Eq. (28)] and Time Zipper 1 [see Eq. (60)], the resulting total zipper contains only original attributes and elements of $H_i$, without new interaction products as a result of the interaction with $H_0$. This deduction is not shown here.

For Time Zipper 2 [see Eq. (61)], the only interesting element is

$$Z_4(t,\mathbf{x},q) = \{O_4, \Omega_4\} = \{\{T, P_i, Q_i\}, \{\varnothing, \varnothing, \partial\mathbf{E}_i/\partial t \propto \nabla \times \mathbf{E}_i\}\}. \tag{94}$$

In $O_4$, the marking set is reduced to charge only because only a major point of space is observable, and in this point, the field is, by definition, zero. The two parts of $Z_4$, which are $O_4$ and $\Omega_4$, are simultaneously observed. In $\Omega_4$, the field is independent of timespace, and combined with $O_4$, the field appears as one vector $\partial\mathbf{e}_i/\partial t \propto \nabla \times \mathbf{e}_i$ attached to $P_i$, so $Z_4$ can be written as

$$Z_4 = \{T, P_i, \{Q_i, (\partial\mathbf{e}_i/\partial t \propto \nabla \times \mathbf{e}_i)\}\}. \tag{95}$$

The vector $\partial\mathbf{e}_i/\partial t$ occurs combined with time attribute

$T$, which is only a single point of time, not a variation of time, so it can only be observed if it is a constant vector. On the other hand, $\partial \mathbf{e}_i/\partial t$ is related to the velocity $\mathbf{v}$ of $P_i$, so a constant velocity is depicted. Thus, indeed, $H_0$ offers the possibility to $H_i$ to have a velocity independent of another charged unit $H_j$. However, the second part of the vector in Eq. (95), the term $\nabla \times \mathbf{e}_i$ is *a new interaction product* not occurring in the original attributes or in the zero genetic set. Because of one of the field conditions [see Eq. (85)] is $\nabla \times \mathbf{e}_i = -\partial \mathbf{b}^i/\partial t$, so as *a changing magnetic vector*, attached to $P_i$. Again, because of time attribute $T$, the change of this vector is constant. Later in this paper, we will identify it with a magnetic spin vector $\mathbf{s}^-$. This result of the interaction with $H_0$ only has consequences for the appearance of $Z_4$. For interactions with $Z_4 = \varnothing$, it has no effect upon charged H-units.

The representation of zip $Z_4$ is appearance $A_4$ with

$$A_4 = \Pi(T, P_i, Q_i, \mathbf{v}, \mathbf{s}^-). \tag{96}$$

This H-event is a point charge $\Pi_P$, having a charge, a velocity, and a magnetic spin.

Considering the results for both Time Cases 1 and 2, we conclude that $H_0$ indeed provides a neutral background for $H_i$. This makes $H_0$ suitable to provide a neutral background for two interacting charged H-units $H_1$ and $H_2$ under the condition that both exist in the major space of $H_0$ without having minor attributes in common with $H_0$. Then both charged H-units may have one and the same velocity, and in principle, they are able to generate stable particles.

However, we must keep in mind that the magnetic spin vectors, resulting from the interaction of $H_1$ and $H_2$ with $H_0$ might influence the interaction products of their mutual interaction. Moreover, we have not yet considered Time Cases 3 and 4, nor interaction types having $s^0 \cap S^i$ and $p_0 \cap S^i$ nonzero.

### C. Reduction of marking attributes

A single H-unit is not observable, which can be compared with the impossibility to see your own face without a mirror. Only by interacting with another H-unit can an observation be generated, and to describe this, we have to insert the attributes of both H-units in the zipper. However, marking attributes are observable only as far as the corresponding timespace elements allow them. If there is nothing to mark, they have no use. To indicate this *reduction*, the marking attributes will be placed between two pairs of broken brackets, one indicating time and one space. If a space object is described, charges and vector fields are restricted to this object. If one part of an observation (classical or complemental) is *time empty*, the corresponding vector field exists independent of time; if both parts of an observation are time empty, no observation exists. Similarly, if one part of an observation is *geometric empty*, the vector fields exist independent of geometry; if both parts are geometric empty, then no observation exists.

By combining the classical with the complementary part, the zip is then ready to interpret, to obtain an appearance. Often, there is more than one interpretation possible, depending on what is considered. In this paper, we are interested in the appearance of mass, so for instance, magnetic field lines are not explicitly considered. If the total zipper contains more than one zip, the interpretations, collected in the set of appearances, obviously must be compatible, which may result in restrictions to the appearances. The final result shows the H-events produced.

## VII. THE GENERATION OF PARTICLES

In this section, Time Case 1 is considered in combination with Space Cases 1 to 4. Also, Timespace Cases (2,1), (2,2), and (3,4) are considered. These cases are selected because they seem the most interesting as a first investigation acquaintance of the extent of the applicability of the model. These cases are assumed to be stable ones, so not emerging in other cases.

We stick to the convention to ascribe charge to mass, so an appearing charge is connected to a minor geometric object if this is available. However, if only a major point of time is described in the zip, charge is connected to this point particle and it is called a *point charge*.

We assume that H-events occurring at major point of time $T$ and those occurring in the flying time $f$ are indistinguishable, so they are considered as simultaneous.

### A. Timespace Case (1, 1)

The H-units in this timespace case have identical time and space attributes. The pellicles have equal radii, so $p_1 \cap p_2 = p$ and $s^1 \cap s^2 = s$. In the marked timespace zipper obtained by combining time zipper [Eq. (60)] with space zipper [Eq. (29)] and marking zipper [Eq. (84)] is $Z_3(t, x, q) = Z_4(t, x, q) = \varnothing$ and in $P$ is by definition $\mathbf{e}_1 = \mathbf{e}_2 = \mathbf{o}$, so the marking in $O_1$ reduces to $Q_1 \propto Q_2$. The result is

$$\begin{aligned} Z(t, \mathbf{x}, q) &= \{Z_1, Z_2\} \\ &= \left\{ \begin{array}{l} \{\{T, P, Q_1 \propto Q_2\}, \{f, \langle s\rangle, \langle\langle \partial\mathbf{E}_1/\partial t \propto \partial\mathbf{E}_2/\partial t\rangle\rangle\}\} \\ \{\{F\backslash T, S\backslash\{P_1, P_2\}, \varnothing\}, \{\tau, \langle p\rangle, \langle\langle \nabla\times\mathbf{B}^1 \propto \nabla\times\mathbf{B}^2\rangle\rangle\}\} \end{array} \right\}. \end{aligned} \tag{97}$$

For *equal charges*, $Q_1 \propto Q_2 = Q \propto Q = Q$. The minor geometric objects are in line with the time attributes, so $\langle s\rangle = s$ and $\langle p\rangle = \pi$. The magnetic fields are not identical due to the principle of uniqueness. Because, in $\Omega_1$ and $\Omega_2$, the geometric objects are nonempty and because of the equal charges and identical geometries $\mathbf{E}_1 = \mathbf{E}_2 = \mathbf{E}$, so

$$\partial\mathbf{E}_1/\partial t \propto \partial\mathbf{E}_2/\partial t = \partial\mathbf{E}/\partial t = \mathbf{M} \tag{98}$$

and

$$\nabla\times\mathbf{B}^1 \propto \nabla\times\mathbf{B}^2 = \partial\mathbf{E}_1/\partial t \propto \partial\mathbf{E}_2/\partial t = \partial\mathbf{E}/\partial t = \mathbf{M}. \tag{99}$$

Combining $O_2$ with $\Omega_2$, the restriction that $\{P_1, P_2\}$ is excluded from $S$ can be dropped because $\pi$ is not existing in the major points. Then the marked timespace zipper can be written as

$$Z(t,\mathbf{x},q)=\left\{\begin{array}{l}\{\{T,P,Q\},\{f,s,\langle\langle\mathbf{M}\rangle\rangle\}\}\\ \{\{F\backslash T,S,\varnothing\},\{\tau,\pi(p),\langle\langle\mathbf{M}\rangle\rangle\}\}\end{array}\right\}. \tag{100}$$

In $Z_1$, the classical part $O_1$ appears as a charged point particle:

$$\{T,P,Q\}\Rightarrow\Pi(T,P,Q), \tag{101}$$

and the complementary part $\Omega_1$ as a linear moving major particle which is neutral because no charge is indicated:

$$\{f,s,\langle\langle\mathbf{M}\rangle\rangle\}\Rightarrow\sigma(f,s,\mathbf{v}_\sigma). \tag{102}$$

Both parts appear simultaneously, so the appearance $A_1$ of $Z_1$ is

$$A_1=\{\Pi(T,P,Q),\sigma(f,s,0,\mathbf{v}_\sigma)\}, \tag{103}$$

which is a charged point particle in the middle of a spherical shaped, linear-moving, neutral major particle. According to our convention, we ascribe $Q$ to the major particle and consider the point particle as neutral. Because the point particle exists inside the major particle, its velocity must be the same. Then $A_1$ can be written as

$$A_1=\{\Pi(T,P,0,\mathbf{v}_\sigma),\sigma(f,s,Q,\mathbf{v}_\sigma)\}. \tag{104}$$

H-events occurring in $T$ and $f$, respectively, are considered as indistinguishable, so we can combine the two appearing particles into one by saying that, in the center of a charged major particle, a neutral point particle appears. The point particle can be considered as a device keeping the two interacting H-units together, like an energetic screw or as glue between their central points. It has no independent existence and $P\in s$, so we neglect it by writing the appearance as

$$A_1=\sigma(f,s,Q,\mathbf{v}_\sigma), \tag{105}$$

which is a linear-moving *charged major particle*.

In zipper $Z_2$, the classical part $O_2$ supplies the future and the major space, so the appearance is completely decided by the complementary part $\Omega_2$:

$$\{\tau,\pi(p),\langle\langle\mathbf{M}\rangle\rangle\}\Rightarrow\pi(\tau,p,0,\mathbf{v}_\pi), \tag{106}$$

and appearance $A_2$ is

$$A_2=\pi(\tau,p,0,\mathbf{v}_\pi), \tag{107}$$

which is a linear-moving *neutral minor particle*, by definition spherically shaped. Then the total appearance is

$$A(1,1,+)=\{A_1,A_2\}=\{\sigma(f,s,Q,\mathbf{v}_\sigma),\pi(\tau,p,0,\mathbf{v}_\pi)\}, \tag{108}$$

in which $(1,1,+)$ indicates subsequently the numbers of time and space cases and the equal charges. The first element gives information about the flying time $f$ and the second about the variation of time $\tau$. They have to be compatible, so minor particle $\pi_p$ exists at the skin of major particle $\sigma_s$; in this zip, another particle appears which seems to be a device to keep $H_1$ and $H_2$ together. The minor particle is lighter than the major one but exists in the same magnetic momentum field, and so its velocity must be larger. This is only possible by traveling through the pellicle over a circle, perpendicular to the movement of the charged major particle, in one of the two possible directions, so $\pi_p$ has *two intrinsic degrees of geometrical freedom*. It might appear as a spin movement of $\sigma_s$. The charged, perfectly spherical-shaped and linear-moving major particle $\sigma_s$ can, for negative $Q$, be identified with an *electron* and, for positive $Q$, with a *positron*. Recent investigations have shown that electrons indeed are spherically shaped.[8] We expect the accompanying minor particle to be observable as well.

To summarize, an electron and a positron can be considered as H-events.

For *opposite charges* $Q_1\propto Q_2=Q-Q=0$ and $\partial\mathbf{E}_1/\partial t=-\partial\mathbf{E}_2/\partial t$, so $\mathbf{M}_1\propto\mathbf{M}_2=\mathbf{O}$ and $\nabla\times\mathbf{B}^1\propto\nabla\times\mathbf{B}^2=\mathbf{O}$. Considering the same Timespace Case (1, 1), the marked timespace zipper is

$$\begin{aligned}Z(t,\mathbf{x},q)&=\{Z_1,Z_2\}\\&=\left\{\begin{array}{l}\{\{T,P,0\},\{f,s,\mathbf{O}\}\}\\ \{\{F\backslash T,S,\varnothing\},\{\tau,\pi(p),\mathbf{O}\}\}\end{array}\right\},\end{aligned} \tag{109}$$

so no charge is observed. Similarly as above, the total appearance can be written as

$$A(1,1,-)=\{\Pi(T,P,0,\mathbf{O}),\sigma(f,s,0,\mathbf{O}),\pi(\tau,p,0,\mathbf{O})\}, \tag{110}$$

in which the minus sign indicates that the charges are opposite. A neutral major particle $\sigma_s$ appears with a point particle $\Pi_s$ in its center, and immediately after that in time, a minor particle $\pi_p$ at the surface. No electric or magnetic features appear. This result coincides with the appearance of two interacting *neutral H-units* [see Eq. (74)], by which the H-event is identified with a dark particle. Thus, a dark particle can be generated in two distinct ways: By two neutral H-units as well as by two oppositely charged H-units. This introduces the possibility that opposite charges are created out of two neutral H-units. Notice that, as a consequence, the zero charge in $Z_1$ can be considered as $Q-Q$ instead of zero, without violating the case. Then the total appearance can be written as

$$\begin{aligned}&A(1,1,-)\\&\quad=\{\Pi(T,P,-Q,\mathbf{O}),\sigma(f,s,Q,\mathbf{O}),\pi(\tau,p,0,\mathbf{O})\}.\end{aligned} \tag{111}$$

This set describes three H-events: A positively charged major particle $\sigma_s$ with a negatively charged point mass in its center and a neutral particle $\pi_p$ at the skin. Further investigation is needed to show if these three events taken together might be identified with a neutron because then it would include the potential that the major particle in a decay process changes into a proton, the point particle into an electron, and the minor particle into a neutrino. This is not further elucidated here.

## B. Timespace Case (1, 2)

H-units in Space Case 2 have major points existing inside minor codomain $s^1\cap s^2$. The marked timespace zipper is obtained by combining Time Zipper 1 [see Eq. (60)] with Space Zipper 2 [see Eq. (30)] and the general marking zipper [see Eq. (84)]. For *equal charges*, we can, similar to the case above, reduce the marked timespace zipper for Time Zipper I to

$$Z(t,\mathbf{x},q) = \{Z_1,Z_2\} = \left\{ \begin{array}{l} \{\{T,\emptyset,\langle\{Q,\mathbf{E}_1\propto\mathbf{E}_2\}\rangle\},\{f,s^1\cap s^2,\langle\langle\mathbf{M}_1\propto\mathbf{M}_2\rangle\rangle\}\} \\ \{\{F\backslash T,S,\emptyset\},\{\tau,\pi(p_1\cap p_2),\langle\langle\mathbf{M}_1\propto\mathbf{M}_2\rangle\rangle\}\} \end{array} \right\}. \tag{112}$$

The marking set $\{Q, \mathbf{E}_1 \propto \mathbf{E}_2\}$ in $O_1$ is restricted by time attribute $T$, a single point of time, so $\mathbf{E}_1 \propto \mathbf{E}_2$ reduces to one vector $\mathbf{e}_1 \propto \mathbf{e}_2$ and the marking set to $\{Q, \mathbf{e}_1 \propto \mathbf{e}_2\}$. There is no geometric object in $O_1$ and, because this marking set is observed simultaneously with $\Omega_1$ (within the flying time), it appears as attached to one single point of minor space intersection $s^1 \cap s^2$, and the charge is ascribed to the major particle, so the appearance is

$$A_1 = \sigma(f,s^1\cap s^2,\{Q,\mathbf{e}_1\propto\mathbf{e}_2\},\mathbf{v}_\sigma). \tag{113}$$

Together with the second appearance, the total appearance is

$$A(1,2,+) = \left\{\sigma(f,s^1\cap s^2,\{Q,\mathbf{e}_1\propto\mathbf{e}_2\},\mathbf{v}_\sigma),\pi(\tau,p_1\cap p_2,0,\mathbf{v}_\pi)\right\}. \tag{114}$$

In the flying time $f$, this is a linear-moving charged major particle $\sigma_{s^1\cap s^2}$ with an electric vector attached to it. In the variation of time ($\tau$) a minor particle $\pi_{p_1\cap p_2}$ appears in the pellicle intersection around the border of the major particle at the surface. In this case, no point particle appears inside the major particle, but again a minor particle seems to keep the two H-units together in the waist of the intersecting minor spaces. Like in Timespace Case (1 , 1), this minor particle is lighter and moves in the same magnetic moment field as the major one, so its velocity must be larger, and for that reason, it circles clockwise or anticlockwise through the pellicle intersection. In this case, only two H-events are produced (instead of three in the previous case), and because the same amounts of potential energy and charges are involved as in Timespace Case (1, 1), the radius of the major particle is expected to be larger. The shape is nonspherical, and because protons are generally known to deviate from a spherical shape, we identify the major particle for positive $Q$ with a *proton* and for negative $Q$ with an *antiproton*. Like in the previous section, these particles can be considered as H-events as well. As with the electron, the accompanying minor particle is expected to be observable.

For *opposite charges*, $Q_1 \propto Q_2 = 0$, and the appearance is

$$A(1,2,-) = \left\{\sigma(f,s^1\cap s^2,\{0,\mathbf{e}_1\propto\mathbf{e}_2\},\mathbf{v}_\sigma),\pi(\tau,p_1\cap p_2,0,\mathbf{v}_\pi)\right\}. \tag{115}$$

This major particle is neutral but electrically active because of the appearance of an electric vector, so the result is not dark matter. It is not possible to consider the zero charge as the sum of two opposite charges and ascribe one of these charges to the minor particle because the first particle is an event in the flying time and the second in the variation of the time. The result is a linear-moving *neutral but electrically active major particle* $\sigma_{s^1\cap s^2}$ in a disclike shape, appearing in the flying time. In the variation of time, a minor particle $\pi_{p_1\cap p_2}$ appears in the pellicle intersection, so at the border of the disc; it has two intrinsic degrees of geometrical freedom [like in Timespace Case (1, 1)], which might appear as the observation of a spin movement of the major particle. It is not yet clear how to identify these H-events.

### C. Timespace Cases (1, 3) and (1, 4)

In Space Cases 3 and 4, $Z_1(\mathbf{x}) = \emptyset$; together with $Z_3(t) = Z_4(t) = \emptyset$ in Time Case 1, the zipper contains only one element:

$$Z(t,\mathbf{x},q) = \{Z_2\} = \{\{\{F\backslash T,S\backslash\{P_1,P_2\},\emptyset\},\{\tau,\pi(p_1\cap p_2),\langle\langle\mathbf{M}_1\propto\mathbf{M}_2\rangle\rangle\}\}\}, \tag{116}$$

and the appearance is

$$A = A_2 = \pi(\tau,p_1\cap p_2,0,\mathbf{v}_\pi). \tag{117}$$

No major mass appears; the neutral minor particle travels through the pellicle intersection in one of the two possible directions, without a restriction to its radius. This is the same type of neutrino as generated by the interaction of two neutral H-units [see Eq. (74)]; the difference is in the magnetic moment field, so in the velocity. We identify this H-event as the *first type of neutrino*.

### D. Timespace Case (2, 1)

In Time Case 2 ($T \in f^1$), the time zipper is [see Eq. (61)]

$$Z(t) = \{Z_2,Z_4\} = \{\{F\backslash T,\tau_1\cap\tau_2\},\{T,\emptyset\}\}. \tag{118}$$

The marked timespace zipper, obtained by combining this with Space Zipper 1 [geometrically identical, see Eq. (29)] and the general marking zipper [Eq. (84)], contains two elements: $Z_2(t, \mathbf{x}, q)$ and $Z_4(t, \mathbf{x}, q)$, but because, in Space Case 1, $Z_4(\mathbf{x}) = \emptyset$, the total zipper contains only one element:

$$Z(t,\mathbf{x},q) = \{Z_2\} = \left\{\{F\backslash T,S\backslash P,\emptyset\},\{\tau_1\cap\tau_2,\pi(p),\langle\langle\mathbf{M}_1\propto\mathbf{M}_2\rangle\rangle\}\right\}. \tag{119}$$

The appearance is a minor particle:

$$A(2,1) = \pi(\tau_1\cap\tau_2,p,0,\mathbf{v}_\pi). \tag{120}$$

$$Z(t,\mathbf{x},q)=\{Z_2,Z_4\}=\left\{\begin{array}{l}\{\{F\backslash T,S\backslash\{P_1,P_2\},\varnothing\},\{\tau_1\cap\tau_2,\pi(p_1\cap p_2),\langle\langle\nabla\times\mathbf{B}^1\propto\nabla\times\mathbf{B}^2\rangle\rangle\}\}\\ \{T,P_2,Q_2\},\{\varnothing,\varnothing,\langle\langle\partial\mathbf{E}_2/\partial t\propto\nabla\times\mathbf{B}^1\propto\nabla\times\mathbf{E}_2\propto\partial\mathbf{B}^1/\partial t\rangle\rangle\}\end{array}\right\}. \tag{121}$$

We identify this H-event as a *second type of neutrino*. It differs in two aspects from the first type: The time interval is smaller, and the pellicle intersection is not a circular track but a complete spherical shape. A smaller time interval could mean that it is a lighter neutrino than the previous one, and hence because of its smaller rest mass, it has a higher velocity; the complete spherical shape means that it has a larger degree of freedom.

## E. Timespace Case (2, 2)

In Space Case 2, both major points exist inside the minor codomain, so $O_4(\mathbf{x})=P_2$. Because, in $P_2$, $\mathbf{e}_2=\mathbf{o}$, the marking set $O_4(q)$ reduces to $Q_2$. The marked timespace zipper is shown in Eq. (121) above.

Appearance $A_2$ of zip $Z_2$ is

$$A_2=\pi(\tau_1\cap\tau_2,p_1\cap p_2,0,\mathbf{v}_\pi), \tag{122}$$

which is a minor particle traveling through the pellicle intersection in one of the two possible directions.

In $Z_4$, the field term in $\Omega_4$ is independent of timespace. It appears simultaneously with $O_4$, so as only one vector at major point of time $T$ in major point $P_2$. If the field is written as $\mathbf{M}_1\propto\mathbf{M}_2+\partial\mathbf{B}^1/\partial t-\partial\mathbf{B}^2/\partial t$, the vector in $P_2$ appears as $\mathbf{m}_1\propto\mathbf{m}_2+\partial\mathbf{b}^1/\partial t-\partial\mathbf{b}^2/\partial t$. It contains two parts: A constant magnetic momentum vector $\mathbf{m}_1\propto\mathbf{m}_2$ related to the linear movement and a time-independent magnetic variation vector $\partial\mathbf{b}^1/\partial t-\partial\mathbf{b}^2/\partial t$. The second vector is, because of $\partial\mathbf{b}^1/\partial t-\partial\mathbf{b}^2/\partial t=\nabla\times(-\mathbf{e}_1+\mathbf{e}_2)$, perpendicular to $(-\mathbf{e}_1+\mathbf{e}_2)$, and because by definition in $P_2$, $\mathbf{e}_2=\mathbf{o}$, it is perpendicular only to $\mathbf{e}_1$. On the other hand, the magnetic vector itself in $P_2$ is $\mathbf{b}^1-\mathbf{b}^2$, and because in $P_2$ by definition $\mathbf{b}^2=\mathbf{o}$, the magnetic vector reduces to $\mathbf{b}^1$, which by definition is perpendicular to $\mathbf{e}_1$. This means that $\partial\mathbf{b}^1/\partial t-\partial\mathbf{b}^2/\partial t$ is in the same plane as $\mathbf{b}^1$, and thus $\mathbf{b}^1$ turns around clockwise or anticlockwise. We identify $\partial\mathbf{b}^1/\partial t-\partial\mathbf{b}^2/\partial t$, causing the turning of the magnetic field, with a *magnetic spin vector*. Then zip $Z_4(\mathbf{x})$ can be written as

$$Z_4(t,\mathbf{x},q)=\{\{T,P_2,Q_2\},\{\varnothing,\varnothing,\mathbf{m}_1\propto\mathbf{m}_2+\mathbf{s}\}\}, \tag{123}$$

where $\mathbf{s}$ is the magnetic spin vector.

Note that if the time sequence of observation of $H_1$ and $H_2$ would be changed, so if $T_1>T_2$, then the other major point $P_1$ with its charge $Q_1$ would be observed in $Z_3$ and $Z_4$ would be empty. The spin vector would be the mirrored one, so $\partial\mathbf{b}^2/\partial t-\partial\mathbf{b}^1/\partial t$. Thus, spin vectors in general occur in two versions: Up and down, indicated by $\mathbf{s}^+$ or $\mathbf{s}^-$, so $\mathbf{s}\in\{\mathbf{s}^+,\mathbf{s}^-\}$, such that if one major point has spin up, then the other has spin down. This can be recognized as the *Pauli exclusion principle*. We introduce the convention that the spin is indicated as $\mathbf{s}^+$ in $Z_4$ because this element is observable in the regular choice $T_2>T_1$, and as $\mathbf{s}^-$ in $Z_3$, which is not observable with that choice. Then $Z_4$ can be written as

$$Z_4(t,\mathbf{x},q)=\{\{T,P_2,Q_2\},\{\varnothing,\varnothing,\mathbf{m}_1\propto\mathbf{m}_2+\mathbf{s}^+\}\}, \tag{124}$$

with $\mathbf{m}_i\in\mathbf{M}_i$ and $\mathbf{s}^+=\partial\mathbf{b}^1/\partial t-\partial\mathbf{b}^2/\partial t$.

The spin vector shows that, in $H_2$, the influence of the interaction with $H_1$ is observable in $P_2$ as a spin vector $\mathbf{s}^+$. The appearance of $Z_4$ is

$$A_4=\Pi(P_2,Q_2,\mathbf{v}_\Pi+\mathbf{s}^+), \tag{125}$$

which is a charged point particle with a magnetic spin, moving with a constant velocity. Then the total appearance (written in the natural time sequence) can be written as

$$A(2,2)=\{\Pi(T,P_2,Q_2,\mathbf{v}_\Pi+\mathbf{s}^+),\pi(\tau_1\cap\tau_2,p_1\cap p_2,0,\mathbf{v}_\pi)\}. \tag{126}$$

At point of time $T$, a charged point particle with magnetic spin appears at $P_2$. A neutral minor particle appears during the common variation of time and travels along the pellicle intersection. For negative charge, we can identify the H-event $\Pi_{P_2}$ as a second way in which an electron can appear: The *electron as a point charge*, without spatial extent, size, or shape, so without mass, which is the traditional way an electron is considered. The H-event $\pi(p_1\cap p_2)$, traveling circular around the track of the electron, can be identified as a *third type of neutrino*, which might coincide with the experimentally well-known electron-neutrino.

## F. Timespace Case (3, 4)

We combine Time Zipper 3 [see Eq. (62)] with Space Zipper 4 [see Eq. (32)] and the general marking zipper [see Eq. (84)]. The two major points exist inside of each other's pellicles, so $r_1=r_2=r$ and $P_{12}=r$. The marked timespace zipper differs only in zip $Z_4$ from the previous case:

$$Z_4(t,\mathbf{x},q)=\{\{T,P_2,Q_2\},\{f^2\cap\tau_1,s^2\cap p_1,\langle\langle\partial\mathbf{E}_2/\partial t\propto\nabla\times\mathbf{B}^1\propto\nabla\times\mathbf{E}_2\propto\partial\mathbf{B}^1/\partial t\rangle\rangle\}\}. \tag{127}$$

The field term in $\Omega_4$ is dependent on timespace; the minor geometric object is non-empty and it occurs combined with interval of time $f^2\cap\tau_1$, so a particle appears. Its shape $s^2 \cap p_1$ is a dot upon the pellicle $P_1$, containing $P_2$ . Combined with $O_4$ the H-event is a mass-carrying particle existing in $s^2 \cap p_1$, having charge $Q_2$, with vector $\mathbf{m}_1 \propto \mathbf{m}_2 + \mathbf{s}^+$ attached to its centre $P_2$. This is a *dot particle* $\delta$. Together with the previously deduced $A_2$ the total appearance is

$$A(3,4) = \{\delta(f^2 \cap \tau_1, s^2 \cap p_1, Q_2, \mathbf{v}_\delta + \mathbf{s}^+), \pi(\tau_1 \cap \tau_2, p_1 \cap p_2, 0, \mathbf{v}_\pi)\}. \tag{128}$$

For negative charge, we could identify this as the third type of an electron; then we call the H-event a *bound electron* because it is part of a shell having $P_1$ as the center point, but also it might be identified with another electronlike particle, like a muon or a tau particle.

## VIII. CONCLUSION

In a previous paper, a mathematical method has been formulated in which uncertainty is interpreted as an independent concept in nature. Heisenberg units (H-units) containing both determinate and indeterminate elements were introduced as being building blocks of the universe, having qualities of time, space, and marking. By doing so, quantization and uncertainty are incorporated in the model, and this concept has been named twin physics.

However, the description of time was rather artificial, being based on real and imaginary numbers and therefore not easily conceivable. In this paper, real time attributes are presented in line with those used for space attributes and yielding a four-dimensional complementary description of observations. Because time is the deciding attribute for the existence of an H-event, the term timespace is introduced instead of spacetime.

To test the model, attention is focused on the description of particles. Timespace is considered as the source of mass by interpreting appearing minor spaces of interacting H-units as particles. The resulting H-events can be interpreted as dark matter particles, neutrinos, neutrons, protons, and electrons. The spin of a particle is found to have two origins: A magnetic and a geometric one. The magnetic spin is shown to obey the Pauli exclusion principle.

Three distinct types of neutrinos are described, and no other types were found by considering more timespace cases. Further research is needed to show whether and how they can be identified as the electron neutrino, the muon neutrino, and the tau neutrino. They have a small but nonzero mass and a velocity less than 1% smaller than the velocity of light. The neutrino is created as an energetic spin-off of an annihilating major particle and travels with a constant velocity, depending on the rest mass of this particle, along a circular track. No interaction with other particles is found, in agreement with the experimental fact that neutrinos can travel great distances through matter.

Electronlike particles also appear in three types: As a perfect sphere, as a massless point charge, and as a dot, which might describe their behavior in different circumstances but also may describe the electron, the muon, and the tau particles.

These theoretical results seem to make twin physics suitable as a unification theory. The three types of H-units (neutral, positive, and negative charge), necessary to produce stable particles, seem to be related to quarks, which are also not independently observable. In contrast to the standard model, the charge of the H-units does not have to be split up, and magnetic spin is caused by their interaction.

Neutral H-units play a crucial role in generating particles: They produce not only dark matter and neutrinos, but also stabilize particles generated by interacting charged H-units.

Because they have a large space, they represent a part of reality which, in the past, often has been neglected. It is reminiscent somewhat to the antique ether, which was assumed to penetrate all bodies without being noticed. Because of its potency to generate stable mass by overlapping charged H-units, this suggests that a Higgs particle is not existing independently, but must be seen as a Higgs-H-unit.

Twin physics is based upon quantum mechanics with the explicit involvement of space, and historical theories can be recognized in it. The laws of Maxwell are anchored in the model; the law of Einstein is represented by the creation of neutrinos out of mass, traveling over a circular track; the many-worlds interpretation can be associated with the many overlapping major spaces which must exist in the universe. Thus, twin physics embraces the existing deterministic view of physics, enriching it with indeterminate aspects.

The theoretical results presented are only a starting point. We restricted ourselves to linear movements of H-units and considered only a few timespace cases. Still lacking are estimations of the size of major and minor spaces, and the only thing that can currently be said of the potential energy of one H-unit is that it is expected to be related to the constant of Planck. There is still a large field to explore.

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