A TUNNEL BETWEEN PHYSICS AND METAPHYSICS: SUPEREMPIRICAL *BEABLES* AND HIDDEN VARIABLES.

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Abstract: The ancient cosmological view that reality is more than quantitative aspects can be explored with an adequate algebraic structure. Here we show that a Weyl algebra can be used to represent the super-empirical (metaphysical) aspects of Saint Thomas´ prime matter and that Bohm's quantum potential intrinsically conveys these super-empirical properties (super-beables). If the proposal is correct, a means to provide an epistemological bridge between philosophical principles inherent to nature and its analysis by physics can be accomplished. In this case, metaphysical attributes do indeed play an essential role ancient cosmology imparted to them, and they can be tracked through the use of an appropriate tool, despite their being definitely "hidden variables" from an empirical point of view, although not hidden from an ontological point of view.

Keywords: Philosophy of Nature – Prime Matter – Ontology – Quantum Potential – Clifford Algebras.

I. INTRODUCTION.

In this paper we endorse that a metaphysical perspective is henceforth necessary as to a thorough understanding of nature, despite truly recognizing that for the last three and a half centuries Western scientific thought has been investigating nature aspects almost exclusively from an experimental point of view. Moreover, this can be especially seen if one takes for granted that physics is able to provide us with the ultimate structural aspects of reality itself. It is certain that this undertaking has given us a quite impressive control over nature's quantitative properties, which is an obvious recognition when we inventory the results from a technological standpoint.

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Though successful it surely has been, nowadays the scientific enterprise strives to overcome increasing perplexities with what might be called *anomalies*, to employ a well-known Kuhnian expression. One of these is the nonlocality effect, which we intend to use as a corner stone to indicate the necessity of a metaphysical reanalysis of the cosmos structure. However, the analysis we intend to carry out in this paper will focus mainly in the Aristotelian concept of prime matter (*prote hyle*), the latter being, according to Aristotle,

> Precisely the ultimate underlying subject, common to all things of Nature, presupposed as their substantive, not incidental, constituent. And again, the destruction of a thing means the disappearance of everything that constitutes it except just that very underlying subject which its existence presupposes, and if perished, then the thing that presupposes it would have perished with it by anticipation before it came to existence (Aristotle, 1957, c9 192a 26-35).

A number of relevant contemporary analysis on Aristotle's concept of prime matter have been carried out in several places (viz. Sokolowski, 1970; Byrne, 1995; Graham, 1987) and the trend, in general, has been towards a distinctive role performed by matter as to being the ultimate physical constitution of the world. Although there have been different perspectives on the kind of *stuff* matter is, whether it is a physical or a metaphysical sort of stuff, little difference exists as to an active engagement of prime matter in the coming to be and passing away of beings. According to Saint Thomas's claim, it is *the ultimate underlying subject, common to all things of Nature*. The purpose of this paper is not to undertake a philosophical discussion on the multiple aspects of Saint Thomas concept of matter (we mean prime matter), but to show that his insights can be developed into a fair understanding of what it really is -- from this point on we will be using *protomatter* instead of prime matter. This should be done in such a way as to allow us to present an algebraic structure that may represent this quit e controversial and obscure concept, as well as have it linked to Bohmian quantum potential.

Our claim is that protomatter is endowed with a finite number of elemental structures that we might call *forms*, in the sense that they fulfill the whole of matter, informing it with the ultimate fundamental aspects of material

existence, basically the set of all qualities that set the corporeal existence in space-time with the attributes we observe or measure. The fundamental approach to be undertaken here is based on the assumption that all qualities within protomatter are either *active* or *passive*, which establishes a dual character for the natural world. This duality can be recognized *bona fide* by the presence of antithetical perception qualities like hot-cold, solid-fluid, or in the experimental detection of positive and negative electrical charges, in the posited Pauli's exclusion principle for orbitals, etc. The basic duality of matter is represented in the algebra by two symmetrical generators (idempotents), and qualities are obtained from them through their product. For an account of the relevant role idempotents can perform for algebraic structures see (Hiley, 2001, p. 107-121).

Based on the algebra as a representation of protomatter, we will show that there exist non-empirical (super-empirical) intrinsic properties (beables). (cf. Bell, 1987) that can not be observed, and that they appear within the quantum potential proposed by David Bohm (cf. Torretti, 1999, and also Hiley apud Saunders and Brown, 1991, p. 217-249). In effect, they appear associated to the quantum potential by conveying these protomatter structural qualities organized as forms to the nonlocal character of this potential. It should also be observed that this association has an outstanding feature: due to the possibility of representing metaphysical qualities through the algebra, these metaphysical attributes show up attached to a by itself *unobservable property* of protomatter meanwhile providing the basis for the *detectable effects* we call nonlocality. We shall present this coupling of unobservable metaphysical properties with observable attributes in the quantum potential in the form of what might be called the bohmian operator of the algebra, which corresponds to the real function $R(\overset{\rho}{x},t)$ of the wave function described by $\psi(\overset{\rho}{x},t) = R(\overset{\rho}{x},t)\exp[iS(\overset{\rho}{x},t)/\eta]$.

However, it is important saying that this is mainly a philosophical paper, basically of the sort ancient cosmology would call *philosophia naturalis*, in the sense that the principles involved here are not subject to strict observational scrutiny. It doesn't mean although that these principles are neither relevant nor should be discarded: nowadays they are staged to perform a comprehensive role in the understanding of nature, as had been foreseen by the ancients.

II. PROTOMATTER AND ALGEBRA.

Before proceeding to the general contents of the algebra, we should

present a quite overall exposure of the metaphysical concepts to be represented. The main ground basis for the discussion is a non-traditional interpretation of Aristotelian protomatter. We claim, based on various insights into the nature of protomatter, that it is endowed with elemental forms, which contain the active and passive qualities (cf. Solmsen, 1960) that are responsible for the combining and transmutation of these forms into matter itself and out to the basic elements of the natural world. The diversity of natural forms arise out of both elemental forms combination and transmutation within protomatter. The natural forms we find everywhere come from these operations upon the elemental forms within protomatter, the former being endowed with specific quantitative determinations which we can observe or measure, despite the latter not. This neither is a problem-free interpretation nor involves concepts that are easy to grasp. In effect, protomatter is the most difficult concept one might try to inquire concerning Nature. Notwithstanding the difficulties involved in this subject matter, the main point for us is that what has been proposed by ancient cosmology can be represented in a due manner through an appropriate algebra, and mostly important, it is sense making and bring about enlightening epistemological consequences.

To begin with, we say that protomatter is a real being; a quite distinctive one to be sure, provided it is not by itself an individual but is part of every natural individual itself, inasmuch as the latter has matter[2]. Hence, it is a *sui-generis* component of reality though it compounds every existing natural kind, be they particles or fields or whatever. Because protomatter endows every natural thing, it is subjected to two radical types of change: creation and annihilation. That is, every natural kind is subject either to coming to be or to be broken up into other natural kinds. This coming to be (or passing away) of natural kinds is made possible because there exists an underlying subject from which and into which natural kinds emerge (creation) or dissolve (annihilation), since *if [it] perished, then the thing that presupposes it would have perished with it by anticipation before it came to existence*, as quoted above from Aristotle. It is this underlying substratum or protomatter that we propose be filled with the ultimate elemental structures (elemental forms) that make possible the coming to be and the passing away of

[2] We use the word matter in this case, instead of protomatter, because we are now referring to matter that appear to us as phenomena, that is, observable, quantitative, measurable matter. That is, phenomenal matter is the outcome of operations within protomatter. In effect, these operations shall provide extensional and moving phenomenal matter, and we show that the left and right ideal operators of the intended algebra can represent them.

natural kinds. These elemental structures are, according to this view, composed with the mixing of dual qualities, some active and some passive, in such a proportion as to make it possible for some of them to be projected onto space-time[3]. This operation of coming to be of mixed elemental forms into an existing real being one calls *eduction*. One should add that eduction consists of a projection unto space-time; this can be accomplished by the use of operators defined in the dual ideal spaces spanned from the algebraic structure. This means also that appropriate projection operators can perform the operations of coming to be (creation) and passing away (annihilation) in the algebra. These operators shall be associated with the dual spaces of the algebra as to provide a *locus* for the projection of the "ready" forms into space-time, or to the receding of them into protomatter. It is not the purpose of this work to present how this could be handled, however we indicate that it could be carried out in such a way as to link it with Hestenes' geometric algebra (cf. Hestenes and Sobczyk, 1987). Activity and passivity are then the two main requisites for protomatter to develop its own dynamics of eduction and breaking up of natural kinds, which means that this fundamental duality shall be represented in the algebra. In addition, a means to represent the basic types of combination and transmutation operations shall be obtained. These considerations on the nature of protomatter allows us to consider it a sort of pre-space structure, which one endows with to be isomorphic with an adequate algebraic structure. This is precisely the kind of approach that can give us very interesting epistemological consequences, as far as quantum theory is concerned (cf. Hiley and Frescura, 1984).

This has been a very high-level presentation of some essential concepts for the development of the main purpose of this work, and it in anyway intends to be a complete or self-contained exposure of the ancient metaphysics. A very concise but precise formulation of the ancient concept of a protomatter ontology can be found, viz. in (Faitanin, 2001). What we shall provide next is some of the necessary algebraic definitions for our intent, and how they can thus be associated with the metaphysical concepts presented so far.

Let us associate the set of elements $\{q_0^1, q_1^0\}$ to our fundamental idempotents that generate the algebra. Well, we have claimed that the elemental forms combine through their active and passive properties the result of which is

[3] We think it is of no less importance to remind that space-time is a quite contemporary word, not available at Aristotle and Saint Thomas' time. However, the coming to be (or passing away) of things into (from) existence is equivalent, from our standpoint, to these changes being performed in the realm of space-time.

a mixture. That is, each elemental form is endowed with a set of active and passive qualities by means of which a combination to produce a mixture obtains. The dual character of activity and passivity is the basis for the dynamics inside protomatter, the latter being represented by an adequate algebra.

We define the Weyl finite algebra C_2^n of order n^2 as the polynomial algebra over the complex field X, spanned by those two previously referred to primitive idempotents, q_0^1 and q_1^0, that represent, as we said, activity and passivity within protomatter, respectively, such that the following relations are obeyed:

$$\left(q_0^1\right)^n = q_0^n = 1$$
$$\left(q_1^0\right)^n = q_n^0 = 1$$
$$q_0^1 q_1^0 = \varphi(p) q_1^0 q_0^1,$$

where $\varphi(p)$ is a complex function over the real parameter p, such that $\varphi(p)\varphi^*(p) = \|\varphi(p)\|^2 = 1$, $\varphi^*(p)$ is the complex conjugate of $\varphi(p)$, and $\varphi^n(p) = 1$, for which $\varphi(p)$ performs a weighting function as we will indicate right below.

Any quality[4] can thus be represented by q_j^k. It means that qualities combine to issue an elemental form, acting as a basis for the algebra. According to Saint Thomas, there are different qualities that generate the simple bodies. Thus we can make a hypothesis that the number of qualities is not fixed, which allows us to label any *k-active-quality* with an upper index *k*, and any *j-passive-quality* with a lower index *j*, where there are *n* indexes and therefore there are n^2 qualities or generators for the algebra.

Also Saint Thomas and Aristotle claim that any elemental form is the result of the mixing of active and passive qualities (cf. Aristotle, 1957, I c6, and also Aquinas, 1998) according to the more and less of each one of them. Each elemental form can be given by a weighted addition of active and passive qualities. This means that any elemental form α_{jk} is an element of the algebra, where indexes *k* and *j* refer to activity and passivity -- wherefore these algebraic elements could be given as matrix elements --, such that any elemental form can be given as

[4] Henceforth we will call these quantities *holoquarks*, for they are the basis for what Davies names *holons* (cf. Davies, 1981), and also because they are the basic blocks upon which elemental forms are built, "confined" (as quarks do) within these forms. (Davies, 1981) has been an invaluable source for our investigation.

$$\alpha_{jk} = \frac{1}{n}\sum_{r}\varphi(r,j,k)q_r^{k-j}, \qquad (1)$$

where $\varphi(r,j,k)$ is the weighting factor which depends on the quantitative mixing of *j* and *k* types of qualities, be they active or passive in the sum.

The reason why the sum is carried into effect on dummy index *r* points out to the fact that there are two fundamental primitive idempotents -- we will call them *holoquarks* from now on --, q_0^1 and q_1^0, that represent the fundamental duality of protomatter, and both are taken as basic for the sum.

Inasmuch as, according to ancient cosmology, elements[5] combine and transmute[6] within protomatter, the algebraic product among any algebraic elements represents these operations. Some of these operations own an especial meaning because they represent combination and transmutation of the elemental forms.

As to the first operation, combination, it can be said that forms may be miscible or not, according to their active and passive qualities. This can be represented in the algebra in the following manner: a certain pure[7] elemental form α_{jj} is either miscible or not with another pure form α_{kk} whether $\alpha_{jj}\alpha_{kk} \neq 0$ or $\alpha_{jj}\alpha_{kk} = 0$, respectively. In a more general way, combination among forms is represented by $\alpha_{ij}\alpha_{kl}$. The idempotent character of each elemental form allows us to conveniently represent that any element is miscible with itself because for any element α_{jj} we obtain that $\alpha_{jj}\alpha_{jj} = \alpha_{jj}^2 = \alpha_{jj}$.

Of course, the main assumption here is that there is an isomorphism from the algebraic elements and their operations as defined above into the structures within protomatter. As up to now there are no ontological laws in the sense of physical laws, the isomorphism assumption conveys what is needed to represent protomatter dynamics.

Another fundamental operation referred to is the transmutation of forms within protomatter, which Saint Thomas considers it to be the fundamental operation responsible for the extraction of compound substantial forms from the potency of protomatter[8], which means that such operation unleashes the fundamental physical structure of space-time reality. Since transmutation is basic

[5] Elemental forms.
[6] That is, they undergo an essential transformation or metamorphosis.
[7] Pure in the sense that both indexes are equal, which means that the form is not the result of a combination of other elemental forms, as we shall see in the sequel.
[8] An operation that Saint Thomas calls *eduction*.

both to extracting physical reality and to keeping proper metamorphoses within protomatter, we represent it by a similarity transformation, following (Bohm, 1980, p. 202) and (Hiley apud Saunders and Brown, 1991, p. 243) suggestions as to express elementary reconfiguration of elements in the algebra. Thus we have for representing the transformation operation, $\varepsilon\alpha_{jk}\varepsilon^{-1}$, where ε is any algebraic element. We get interesting transmutations if we take ε to substitute for the primitive holoquarks q_0^k and q_j^0, which is consistent with the hypothesis that both *k-activity* and *j-passivity* of the qualities act as triggers for the eduction of a new being into space-time realm.

Let us then define the idempotents operations in the algebra in the following manner, for any elements in the algebra,

$$\alpha_{ij}\alpha_{kl} = \delta_{jk}\alpha_{il}$$
$$\alpha_{jj}\alpha_{jj} = \alpha_{jj}$$
$$\alpha_{jj}\alpha_{kk} = 0, \qquad jj \neq kk$$
$$\sum_{j=0}^{n-1}\alpha_{jj} = 1.$$

Where δ_{jk} is the Kronecker symbol: 1, if $j = k$; and 0, if $j \neq k$.

The fact represented by $\sum_j \alpha_{jj} = 1$ is that all elemental forms are needed to map the whole of protomatter, which is in accord with the assumption that protomatter is not pure potency -- as many have interpreted wrongly --, since it *is. Being* is an ontological requisite of protomatter, inasmuch as this ``minimum" ontological being is responsible for its both activity and eduction of the whole of Nature, as proposed.

We can obtain also some other set of idempotents α'_{jk} by simply performing the automorphism $\alpha'_{jk} = \varepsilon\alpha_{jk}\varepsilon^{-1}$, where ε is any element of the algebra. In effect, by taking ε to be the primitive holoquarks (or idempotents) q_0^1 and q_1^0 we get very rich consequences as to the understanding of the tasks performed by dual spaces inside protomatter, which we can associate with position and momentum for instance. A more detailed account of these dual spaces one can find in (Petronio, 2008, p.144-150, p. 194-204).

We can adequately interpret the role of the Kronecker symbol if we take the null components as an expression for the representation of the non-miscibility of the forms, while the unitary components an expression for the representation of the miscibility of the forms.

We get from the non-commutative character of the Weyl algebra that

$$q_0^1 q_1^0 = \varphi(p) q_1^0 q_0^1.$$

Where $p \in \mathrm{P}$ and $\varphi(p) = \exp\left(\frac{-2\pi i}{n} p\right)$

In this case, any holoquark q_k^j can be defined by

$$q_k^j = q_0^j q_k^0 = \varphi^{jk} q_k^0 q_0^j. \quad (2)$$

Also, any pair of holoquarks can combine according to the following rule[9]

$$q_j^i q_l^k = \varphi^{-jk} q_{j+l}^{i+k}. \quad (3)$$

Since the holoquarks work as a basis for the algebra, then one can show that any algebraic element $\varepsilon \in \mathrm{A}$, A is the spanned algebra, can be given by

$$\varepsilon = \sum_{j,k=0}^{n-1} A_{jk} q_k^j. \quad (4)$$

.However, we are interested in the elemental forms α_{jk}, which can be obtained from the holoquarks by the following expression[10]

$$\alpha_{jk} = \frac{1}{n} \sum_{r=0}^{n-1} \varphi^{-kr} q_r^{k-j}. \quad (5)$$

The above proposed expression for an elemental form α_{jk}, be it pure or not, is consistent with the claim that elemental forms can be seen as the mixing of the qualities according to certain proportions among them. The weighting factors φ^{-kr} represent in their superior indexes *k* and *r* that required mixing proportion of active and passive qualities or holoquarks. If we make *j*=*k*, we get

$$\alpha_{jj} = \frac{1}{n} \sum_{r=0}^{n-1} \varphi^{-jr} q_r^0. \quad (6)$$

This represents a pure form. It is interesting to notice that a pure form is but a combination of only one type of duality, be it passive or active, as is indicated by the 0-index. In this case, α_{jj} is a pure form obtained through the weighting of pure passive holoquarks, that is, the q_r^0 qualities. In this sense, α_{jj} is a *pure passive* form. Let us then show that $\alpha_{jj} = q_0^{-j} \alpha_{00} q_0^j$. Well, according to the expression [6] above, if we take *j*=0, we get,

$$\alpha_{00} = \frac{1}{n}\left(q_0^0 + q_1^0 + \ldots + q_{n-1}^0\right).$$

If we left multiply both sides by q_0^{-j} one obtains

[9] Detailed accounting of the relations presented so far one can find in (Davies, 1981).
[10] See (Davies, 1981., p. 87-91).

$$q_0^{-j}\alpha_{00} = \frac{1}{n}\left(q_0^{-j}q_0^0 + q_0^{-j}q_1^0 + \ldots + q_0^{-j}q_{n-1}^0\right).$$

If we right multiply both sides by q_0^j one obtains

$$q_0^{-j}\alpha_{00}q_0^j = \frac{1}{n}\left(q_0^{-j}q_0^0q_0^j + q_0^{-j}q_1^0q_0^j + \ldots + q_0^{-j}q_{n-1}^0q_0^j\right),$$

$$q_0^{-j}\alpha_{00}q_0^j = \frac{1}{n}\sum_r q_0^{-j}q_r^0q_0^j.$$

However, $q_k^j = q_0^jq_k^0 = \varphi^{jk}q_k^0q_0^j$, and if we also substitute *--j* for *j* we get[11]

$$q_0^{-j}q_r^0 = \varphi^{-jr}q_r^0q_0^{-j}.$$

Carrying this last result to the above sum, one has that

$$q_0^{-j}\alpha_{00}q_0^j = \frac{1}{n}\sum_r \varphi^{-jr}q_r^0q_0^{-j}q_0^j.$$

And, according to the given definition for the algebra primitive idempotents,

$$q_0^{-j}q_0^j = \varphi^0 q_{0+0}^{-j+j} = q_0^0 = 1.$$

Wherefore we have

$$q_0^{-j}\alpha_{00}q_0^j = \frac{1}{n}\sum_r \varphi^{-jr}q_r^0.$$

However, the right-hand side of expression above is α_{jj}. Thus, one obtains that

$$\alpha_{jj} = q_0^{-j}\alpha_{00}q_0^j. \qquad (7)$$

In a similar way, one can show that

$$\alpha_{jk} = q_0^{-j}\alpha_{00}q_0^k. \qquad (8)$$

It happens thus that α_{00} seems to perform a very important task of linking elemental forms through the automorphisms [7] and [8] above, such that we have not been concerned with any space-time constraints so far, that is, we have not been attached to any previous metric structure, due to the pre-geometric character of the algebra. The role to be performed by elemental forms of the type α_{jj}, as they span the whole space of the algebra, should not be neglected. In effect, they seem to work as a kind of pervasive interaction within protomatter, building up, together with holoquarks q_k^0 and q_0^j, the fundamental physical stuff of Nature. Now, it is important to set the devices through which we will be able

[11] One allows these types of substitutions (j for --j, j for j-k, etc.) because of the cyclic character of the sum, since there are a finite number of elements in the algebra.

to derive metric structures (linear spaces) from the algebra. The metric structures can thus be associated to space-time quantitative determinations, which is a most desirable thing inasmuch as it allows us to observe and measure. The appropriate devices for this task are the left and right ideals of the algebra, defined as follows:

$$R_0(k) = \frac{1}{n}\sum_s \varphi^{ks} q_{-s}^{k}, \tag{9}$$

$$L_0(j) = \frac{1}{n}\sum_r q_r^{-j}. \tag{10}$$

It can be shown that the right and left ideals as defined above correspond respectively to the *bra* $\langle\ |$ and *ket* $|\ \rangle$, viz. the Dirac symbols of quantum mechanics[12], that is, $|j\rangle = L_0(j)$ and $\langle k| = R_0(k)$. It also can be shown that the idempotents are obtained from the ideals so that

$$\alpha_{jk} = L_0(j)R_0(k) = |j\rangle\langle k|. \tag{11}$$

We can prove the result right above by observing that, by taking the definitions of left and right ideals and multiplying both, we obtain

$$\begin{aligned} L_0(j)R_0(k) &= \frac{1}{n^2}\sum_{r,s} \varphi^{ks} q_r^{-j} q_{-s}^{k} \\ &= \frac{1}{n^2}\sum_{r,s} \varphi^{ks}\varphi^{-rk} q_{r-s}^{k-j} \\ &= \frac{1}{n^2}\sum_{r,s} \varphi^{-k(r-s)} q_{r-s}^{k-j}. \end{aligned}$$

Thus if we take $t=r-s$ and substituting for in the last parcel, we obtain that

$$L_0(j)R_0(k) = \frac{1}{n}\sum_t \varphi^{-kt} q_t^{k-j}. \tag{12}$$

Then, if one compares with expression [5], one obtains α_{jk}. We take up these algebraic components to denote *super-empirical (metaphysical) beables* existing within protomatter, that is, real principles and properties that *de facto* underlie physical reality in the way proposed by Saint Thomas. Those beables are the ultimate structural elements within protomatter, which we have shown to be given by active and passive holoquarks and elemental forms. From an algebraic point of view, ideals and other operators are introduced to account for further properties.

[12] One finds in (Davies, 1981, p. 97-99) a more detailed demonstration of the Dirac's brackets.

III. SUPER-EMPIRICAL BEABLES AND BOHM QUANTUM POTENTIAL[13].

In an effort that has been under development for many decades, carried out by David Bohm (until his death in 1992) and his collaborators, an ontology was sought to describe individual quantum processes. As part of the research, (Bohm, 1952) proposed a new kind of potential or field that would allow the form of the field to interact with the quantum system, and the main characteristic of the interaction was that it was nonlocal. This seemed to introduce a hidden variables approach to allow for the following aspects:

(A) It is supposed that the wave function ψ represents a field that is objectively real, and that it is not the case the wave function is only a mathematical symbol to accommodate some physical properties of the quantum object;

(B) It is supposed that because of the presence of the field described by the wave function, there exists a particle that is given by a set of always well defined and varying coordinates;

(C) The velocity of the particle depends on a phase function S, linked to the wave function ψ such that $\psi = Re^{iS}$, where S and R are real, and R is the amplitude of the quantum potential, and this latter defines the form of the wave function;

(D) The field ψ is in effect in a state of very fast and chaotic fluctuation. The values that are used to express ψ are a kind of average, taken over some time interval that is long enough if compared to the average intervals of the fluctuations that emerge from the quantum potential, but short enough if compared to usual quantum processes.

Therefore, Bohm suggested that this quantum potential Q might be expressed by

$$Q = \left(-\eta^2 / 2m \right)\left(\nabla^2 R / R \right) \qquad (13)$$

Where m is the particle mass, $\eta = h/2\pi$, h is Planck's constant, and R is the field amplitude (see Durr et al, 2004). Let us propose a link between this field potential and super-beables. Some premises are necessary:

(i) There is an operator $\hat{R}$ that can represent quantum potential within protomatter, viz. it is an element of the algebra, although it does not share a similar form with operators that represent quantum mechanical field forces and

[13]The seminal work of Bohm on this subject matter can be found on a detailed basis in (Bohm, 1952).

energy;

(ii) The operator $\hat{R}$ should meet primarily the requisite of *form* for the field at a determined place in the configuration space;

(iii) The operator $\hat{R}$ should meet the algebraic expression for the wave function in the configuration space, which can be given by (cf. Davies, 1981, p. 205)

$$|\psi\rangle = \frac{1}{n}\sum_{j,u}\psi_j q_u^{-j}.$$

Where $\psi_j = a_j e^{-ij^2 t/2m}$, a_j is a constant, t and m are certain parameters (t represents time and m the quantum system mass). If we substitute it for the expression of the wave function, and making $\lambda = t/2m$, we obtain

$$|\psi\rangle = \frac{1}{n}\sum_{j,u} a_j e^{-i\lambda j^2} q_u^{-j}. \qquad (14)$$

However, if one compares it to the expression Bohm suggested for the wave function, one obtains

$$\frac{1}{n}\sum_{j,u} a_j e^{-i\lambda j^2} q_u^{-j} = \hat{R}e^{iS}.$$

Wherein we right multiply both sides by e^{-iS} and rearrange to get

$$\hat{R} = \sum_j a_j e^{-i\left(\lambda j^2 + S\right)} q_0^{-j} \frac{1}{n}\sum_u q_u^0.$$

If we make $\eta_j(\lambda, S) = a_j e^{-i\left(\lambda j^2 + S\right)}$ and takes into account that $\alpha_{00} = \frac{1}{n}\sum_u q_u^0$, then we have,

$$\hat{R} = \sum_j \eta_j(\lambda, S) q_0^{-j} \alpha_{00}. \qquad (15)$$

On the other hand, it should be noticed that according to (Davies, loc. cit.) and (Petronio, 2008, p. 224), $q_0^{-j}\alpha_{00} = |j\rangle$, which implies that

$$\hat{R} = \sum_j \eta_j(\lambda, S)|j\rangle = \sum_j \psi_j |j\rangle.$$

Equation [15] above meets not only the criteria we devised in the listed premises, as well as it describes the simultaneous nonlocal character of both the elemental form (super-beable) α_{00} and the holoquarks (super-beables) q_0^{-j}, since they are not given based upon any assumption on space-time restrictions. It describes as well the local character represented by λ and S, which may be calculated according to some stochastic algorithm, taking into account the

deterministic form of S and the statistical form of λ.

By multiplying the right side of equation [15] by $q_0^j q_0^{-j} (=1)$, we obtain

$$\hat{R} = \sum_j \eta_j(\lambda, S) \underbrace{q_0^{-j} \alpha_{00} q_0^j}_{\alpha_{jj}} q_0^{-j}.$$

Wherefore Bohm operator in the algebra is given by

$$\hat{R} = \eta_j(\lambda, S) \alpha_{jj} q_0^{-j}. \quad (16)$$

We have adopted Einstein's convention sum for dummy index j in the above expression. If we take $\hat{R}$ to be presented as a function both of the locally describable parameters λ, S, and the nonlocal ("hidden") parameters $\sigma_j = \alpha_{jj} q_0^{-j}$, then we may write

$$\hat{R} = R(\lambda, S, \sigma_0, \sigma_1, ..., \sigma_{n-1}). \quad (17)$$

Equation [16] above is quite simple in its form and describes the simultaneous nonlocal and local character of the quantum potential, since Bohm's operator is a function of a set of parameters, some of them local, λ, S, and some other nonlocal, $\sigma_0, \sigma_1, ..., \sigma_{n-1}$. Moreover, (Bell, 1987, p. 63-66) has shown that this sort of hidden parameters σ_j, as we have considered in expression [17], are definitely non-local. To put it more explicitly: The super-beables α_{jj} and q_0^{-j} are responsible for the type of nonlocal "form interaction" character of the Bohm operator $\hat{R}$, and are hidden variables in the sense that they are super-empirical factors that reside inside protomatter (or inside holomovement, which means the same for the time being, cf. Bohm and Hiley, 1993, p. 350-367). This means that they cannot be detected by any experimental or measurement process. Only $\eta_j(\lambda, S)$ or related operators in Hilbert spaces are subject to observation or measurement, whereas super-beables are not, and most important of all: as far as the pre-metric character of the algebra is concerned, these latter cannot be tracked by any measurement process, presently or in the long run. In a certain way, they are similar to quarks[14], inasmuch as they are definitely confined within the ontological (metaphysical) realm of protomatter.

What we have done so far with the use of the passive primitive idempotent q_1^0 can be obtained on a dual basis with the use of the active primitive idempotent q_0^1, so as obtain a space with elements β_{jj}, such that

[14] The terminology gets clearer though: similarly to the nucleus-confined quarks, holoquarks (the qualities that builds up forms within protomatter) are protomatter-confined super-beables.

$$\beta_{jj} = \frac{1}{n}\sum_{s}\varphi^{-js} q_0^s .$$

It can be shown that these algebraic elements span the dual of the α_{jj} space, so that we can interpret passive α_{jj} as generating the extensional properties of matter and active β_{jj} as generating the mutability properties of matter. We shall present this on a detailed basis in a future paper. The main point here is to call forth the attention to the fact that matter is both extended and mutable, and these intrinsic aspects are dual in the sense that they can not subsist one without the other, as far as Nature is concerned. We conjecture whether this intrinsic dual character of matter shall not be responsible for the basic duality of position and momentum we find in quantum mechanics, the latter stated in the form of the Heisenberg principle.

IV. CONCLUDING REMARKS.

We think that what we have presented so far clearly suggests that a deeper insight into metaphysical aspects of matter may lead us to a new area of investigation, on which a kind of complementarity between experimental processes and metaphysical analysis should be taken over, despite of prejudices that have been around for more than three centuries. Of course, the purpose of this paper is neither to have established a comprehensive perspective on how this could be accomplished on a detailed basis, nor to have carried out a deep investigation on the algebraic structures that can be put on place to represent protomatter. Our only intent has been to provide an overall approach to this subject matter.

On the hand, we understand that there is enough room for evolving with the protomatter mathematical modeling, as well as investigating some experimental procedures to detect the effects of the super-beables, granting that none of them would be ever detected in itself. However, if the right tools were developed, we could track their presence as a disturbing interference that causes nonlocal correlations, or other kinds of detectable effects. Perhaps, perturbation and stochastic methods can be of invaluable help on this effort of detection. Anyway, we expect that very soon indeed mathematical modeling will provide us with some kind of bridge between super-beables and detectable disturbances caused by their presence. In this respect, we think that a survey on the vacuum ground state could indicate which way to follow by specifying the role performed

by the ``hidden" $\sigma_0, \sigma_1, ..., \sigma_{n-1}$ components. Perhaps they appear associated to creation and annihilation operators, respectively, a_k and $a_k^\dagger$, since for a dynamic vacuum, if $a_k|0\rangle = 0$ and $\langle 0|a_k^\dagger a_k|0\rangle = 0$, then both a_k and $a_k^\dagger$ are $\neq 0$.

John Bell was right: There is no place for claiming that physical beables might save both locality and quantum mechanics. Therefore, one solution could be to take up super-beables as non-physical (metaphysical) elements of a reality that extends itself beyond measurements carried out in the realm of space-time. In this case, both aspects of physical reality are saved from a quantum-mechanical standpoint: The nonlocal correlations, which pertain to the non-measurable ontological order, and the local predictions, which pertain to the measurable physical order.

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