PHYSICAL GEOMETRY OF THE SYNTHETIC BIOQUANTUM FRAME

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Résumé : Nous donnons ici les principales propriétés géométriques du cadre physique de la synthèse bioquantique, en commençant par le cas élémentaire (non structuré). S'ensuit une discussion physique des résultats obtenus, puis l'étude du cas structuré, réduite au simple minimum grâce à l'utilisation d'une astuce due à Prigogine. Enfin, nous présentons la *dualité onde-matière*, extension structurée en dimension complexe de la dualité onde-corpuscule de Louis de Broglie.

Abstract : We give here the main geometrical properties of the physical frame of the bioquantum synthesis, beginning with the elementary (i.e. non structured) case. Follows a physical discussion of the obtained results, then the survey of the structured case, reduced to the very minimum thanks to the use of the Prigogine trick. Finally, we introduce the *wave-matter duality*, a structured extension in complex dimension of Louis de Broglie's wave-corpuscle duality.

0 – Introduction

The very first mathematical model unifying the four known fundamental interactions into a single geometrical frame with a natural supersymmetric extension to include fundamental matter fields was proposed in [V1], in the context of Einstein's general relativity. Physical processes were still assumed to be elementary, meaning that complexity was not taken into account yet. Two years later, the first bioquantum theory was built and it was historically the first to be consistent with physics, mathematics and observation at all scales. A large-public book was written, showing the applications of the theory to parapsychology, its most extreme case [V2]. That was the first attempt to insert complexity into the physical world, within the frame of Nottale's scale relativity, a natural extension of Einstein's space-time relativity. However, this model was still deeply anchored in the physics of the 20th century. Consequently, it was rather big and heavy to handle: rather big, for it had 16 dimensions (17 including complexity); heavy to handle, for it required to distinguish all the time between "space-like", "light-like" and "time-like" directions. But the mathematical proof that time could be eliminated from the physical frame to the benefit of the Universal Vacuum, in October 2003, changed everything [V3] and a second bioquantum theory, better called the *bioquantum synthesis*, quickly came to replace the old version. That second "theory of everything" (everything known, of course) also showed to be the final one, as it appeared to be *minimal*, *natural* and *easy to handle*, while being much more powerful and simple than the first one, that already managed to explain no less than fourty-two parapsychological phenomena (including of course Extra-Sensorial Perception or ESP – telepathy, remote viewing, precognition and retrocognition -, telekinetics and psychokinetics). All this work clearly showed that one did not need a "new physics with still unknown properties", as was believed by many experts, but rather a complete and thorough *reorganization* of fundamental physics, covering the three last centuries, from Galileo Galilei up to our days. This is explained in details in the large-public book [V4]. So, let us now turn to the bioquantum synthesis.

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1 – The Elementary Quantum World QW_0

We start out with the mathematical definition of the Elementary Quantum World.

Definition 1: The *Elementary Quantum World* QW_0 is a 9-dimensional complex manifold with Euclidian signature equipped with vielbein forms $e = e_I(z,z^*)dz^I$ and $e^* = e^*_I(z,z^*)dz^{*I}$, the mirror symmetry M which exchanges any point z of QW_0 with its complex conjugate (c.c.) z* (and conversely) and a complex scalar field V: QW_0 -> **C** such that QW_0 has conformal hermitian metric:

(1) $dS_0^2 = \exp(-|V(z,z^*)|^2).ds^2$, $ds^2 = Tr(|e|^2) = g_{IJ}(z,z^*)dz^I dz^{*J}$

in a local reference frame, where

(2) $g_{IJ} = Tr_9(e_I e^*_J) = (g_{JI})^*$ and $Tr_9(e_I e^{*J}) = \delta_I^J$ (I,J = 1,...,9)

the trace being that of SU(9), the local invariance group of QW_0.

Proposition 1: V is the vacuum state of the vielbein e.

Proof:
i) Suppose that this is the case. Then, we have a propagator [LL1]:

(3) $<0|Tr_9(e_I e^*_J)|0> = D_{IJ} = g_{IJ}|V|^2 – D_I D^*_J|V|^2$

It follows that $|V|^2$ is a Green function, that is, a solution of the wave equation on QW_0:

(4) $D_I D^{*I}|V|^2 = 0$

A simple calculation shows that the conformal scalar curvature W of QW_0 is:

(5) $W = e^{|V|^2}(R + 8D_I D^{*I}|V|^2 + 14D_I|V|^2 D^{*I}|V|^2)$

with D and D*, the Levi-Civita connexions on QW_0 and R, the scalar curvature of ds^2. Inserting (4) into (5) gives:

(6) $L = e^{-|V|^2}W = R + 14D_I|V|^2 D^{*I}|V|^2$

The function L is the conformal Lagrangian. Indeed, when V = 0, L reduces to the Lagrangian L_0 = R of ds^2. When V is non zero, the second term on the right is the kinetic energy of $|V|^2$. Besides, in empty space, R = 0 and the kinetic term makes the full Lagrangian, as expected.
ii) Conversely, consider the conformal Lagrangian:

(7) $L = e^{-|V|^2}W = R + 8D_I D^{*I}|V|^2 + 14D_I|V|^2 D^{*I}|V|^2$

Canonical momenta being:

(8) $P_0 = \partial L/\partial[D_I D^{*I}|V|^2] = 8$, $P_I = \partial L/\partial[D^{*I}|V|^2] = 14D_I|V|^2$

it follows that the Lagrange equations:

(9) $D_I D^{*I} P_0 – 2D_I P^{*I} = 0$

lead to the wave equation (4). Therefore, $|V|^2$ is a Green function with propagator:

(10) $D_{IJ} = g_{IJ}|V|^2 – D_I D^*_J|V|^2 = <0|Tr_9(e_I e^*_J)|0>$

since the vielbein forms e and e* are the only fundamental metrical datas on the base manifold of QW_0 defined by V = 0.

<u>Definition 2</u>: V is the *Universal Vacuum*, that is, the gravitational vacuum on QW_0.

<u>Proposition 2</u>: SU(n,1) can be canonically generated as an infinitesimal deformation of SU(n) with parameter V at the limit V -> 0.

We will establish the proof in the case n = 9, the general case being straightforward. Developing (1) to the first order near V = 0 gives the following infinitesimal deformation of the base metric ds^2:

(11) $dS_0^2 = [1 – V^2 + O(V^4)]ds^2 = ds^2 - V^2ds^2 + O(V^4)ds^2$

where $O(V^4)$ contains all higher-order terms in V^{2p}, with p integer > 1. These terms are negligible. The presence of the negative sign before V^2 clearly shows that dS_0^2 is not invariant under the action of SU (9), but under that of the larger non-compact group SU(9,1). Indeed, if we introduce a 10th complex space variable (z^0,z^{*0}) such that:

(12) $dz^0 = \pm V(z,z^*)e = \pm V(z,z^*)e_I(z,z^*)dz^I$, $dz^{*0} = \pm V^*(z,z^*)e^* = \pm V^*(z,z^*)e^*_I(z,z^*)dz^{*I}$

at any point (z,z*) of QW_0, then the surface element ds^2- V^2ds^2 is a hyperbolic metric in a so-called *synchronous coordinates system* (or *frame*) with coefficients:

(13) $h_{IJ} = g_{IJ}$, $h_{I0} = h_{0I} = 0$, $h_{00} = -1$, $h_{I0} = (h_{0I})^*$

Therefore, it is locally invariant under the action of SU(9,1). Since there is a two-way canonical transformation that enables one to go from a synchronous frame to a general one and back ([LL2], page 373), the metric $ds^2 - |dz^0|^2$ is left invariant by SU(9,1) in any associated frame $(z^I,z^0;z^{*I},z^{*0})$ and so, it identifies with the hermitian space-time metric in complex dimension 9. □

<u>Definition 3</u>: The complex coordinate (z^0,z^{*0}) defined by (12) is called the *complex physical time*.

As $\dim_{\mathbb{C}}(QW_0) = 9$, one has a canonical tensor decomposition:

(14) $QW_0 = OW_0 \otimes IW_0$

with $\dim_{\mathbb{C}}(OW_0) = \dim_{\mathbb{C}}(IW_0) = 3$, which identifies any point $z^I = (z^1,\ldots,z^9)$ of QW_0 with the point (z^{ia}) of the tensor product, with i running from 1 to 3 and a taking values -,0,+.

<u>Definition 4</u>: OW_0 is called the *Elementary Outer World* and IW_0, the *Elementary Inner World*. □

The tensor decomposition (14) is formally equivalent to the Euclidian product:

(15) $QW_0 = OW_0^{(-)} \times OW_0^{(0)} \times OW_0^{(+)}$

of Elementary Outer Worlds. This means that the Elementary Outer World OW_0 can appear in three *internal configuration states*, (-), (0) and (+) and that the Elementary Quantum World can be viewed as the coupling of these three internal configuration states. Still equivalently:

(16) $QW_0 = IW_0^{(1)} \times IW_0^{(2)} \times IW_0^{(3)}$

shows this time that the Elementary Inner World IW_0 can appear under three *external projections*, each one along a (complex) direction of OW_0.

Definition 5: The canonical decomposition (15) is called the *objective representation* of QW_0 and the canonical decomposition (16), the *subjective representation* of QW_0.

Proposition 3: QW_0 is supersymmetric.

Proof: Let p: QW_0 -> OW_0 be the external projection, $e' = p(e) = e'_i(z',z'^*)dz'^i$ (and c.c.) be the vielbein forms on OW_0 and $ds'^2 = g'_{ij}(z',z'^*)dz'^i dz'^{*j}$ the corresponding metric, with $g'_{ij} = Tr_3(e'_i e^{*\prime}_j)$ and $Tr_3(.)$, the trace of SU(3). Let q: QW_0 -> IW_0 be the internal projection, $e'' = q(e) = e''_i(z'',z''^*)dz''^i$ (and c.c.) be the vielbein forms on IW_0 and $ds''^2 = g''_{ij}(z'',z''^*)dz''^i dz''^{*j}$ the corresponding metric, with $g''_{ij} = Tr_3(e''_i e''^*_j)$. SU(3) is the local invariance group of both OW_0 and IW_0. We will limit ourselves to OW_0 as the proof is similar for IW_0. ds'^2 can be canonically decomposed into:

(17) $$ds'^2 = h'_{ij}(x',y')(dx'^i dx'^j + dy'^i dy'^j) + \varepsilon'_{ij}(x',y')(dx'^i dy'^j - dx'^j dy'^i)$$

where $x' = Re(z')$, $y' = Im(z')$, $h'_{ij} = Re(g'_{ij})$ and $\varepsilon'_{ij} = Im(g'_{ij})$. Hermiticity of g'_{ij} , inherited from that of g_{IJ} by external projection, implies that $h'_{ij} = h'_{ji}$ and $\varepsilon'_{ij} = -\varepsilon'_{ji}$. The first part of (17) therefore represents the symmetric ("bosonic") part of the metric, while the second part of (17) represents the skew-symmetric ("fermionic") part of it. One has a SO(3)-symplectic structure given by the 2-form $\varepsilon' = ½\, \varepsilon'_{ij}(x',y')(dx'^i dy'^j - dx'^j dy'^i)$. As $SO(3) \approx SU(2)/\mathbf{Z}^2$, this symplectic structure is equivalent to a spin-1/2 structure. One gets a similar result for IW_0. The difference between the two spin structures stands in their physical representation: on OW_0, the fermionic structure represents the physical *corpuscle*, whereas on IW_0, it represents the physical *wave*. The duality between OW_0 and IW_0 is the de Broglie wave-corpuscle duality (or Feynman's quantization formalism, in the general situation of continuous fields): the phase angle of the wave function is the ratio of a "classical" (i.e. corpuscular) action and of Planck's reduced constant $h/2\pi$. See section 4 below. Sending the spin-1/2 structures on OW_0 and IW_0 back to QW_0, one finally obtains a single spin structure on QW_0 given by the 2-form $\varepsilon = ½\, \varepsilon_{IJ}(x,y)(dx^I dy^J - dx^J dy^I) = p^{-1}(\varepsilon') = q^{-1}(\varepsilon'')$, with $z^I = x^I + iy^I$ (I = 1,…,9). However, ε defines a SO(9)-symplectic structure on QW_0, isomorphic to a $SO(4)\otimes SO(4)$-structure or to a G^3-structure, where $G^3 = GxGxG$ and G = SO(3)xSO(3)xSO(3)xSO(3) = $[SO(3)]^4$, which shows that the spin structure on QW_0 is no longer elementary but composite, made of no less than 12 (=3x4) coupled spin-1/2 structures. □

These twelve spin-1/2 structures can therefore be attributed to the six leptons (e,ν_e) , (μ,ν_μ) , (τ,ν_τ) and to the six quarks (u,d,s,c,b,t) up to the sign, which makes 24 charged fundamental fermions. This is an additional argument in favour of a maximum of three families of leptons in the universe. The mirror symmetry M then makes sure that there is an equal number of particles with positive energy and of "antiparticles", i.e. particles with negative energy, in QW_0. As all 24 particles interact, they transform into each other, which is precisely what is expected from a unified theory of both matter and radiation fields. Notice in passing that SO(9) has $SU(5)/\mathbf{Z}^2$ has a subgroup, which fits with the SU (5)-model of Grand Unification Theory (GUT) too.

Proposition 4 (self-polarization of the Universal Vacuum): $|V|^2$ is a Kähler potential.

Proof: It is shown in [WB], pages 167-169 that a Weyl rescaling of the vielbein e generates a Kähler potential K. In (1), the scale factor acting on the vielbein forms e and e* is $\exp(-|V|^2/2)$, so that the dynamical variables corresponding to the authors'λ is now $-|V|^2/2$ from where we deduce that $\Omega = -3\exp(-2\lambda) = -3\exp(|V|^2)$. As a result, the Kähler potential $K(z,z^*) = -3Ln(-\Omega/3) = -3|V(z,z^*)|^2$. Conversely, suppose $|V|^2 = -K/3$ is a Kähler potential. Then, as shown by the authors, a rescaling of the vielbein e -> $e.\exp(-|V|^2/2)$ is required in order to normalize the gravitational action in the kinetic part (21.13) of the general chiral N = 1 supergravity Lagrangian, removing the unconventional Brans-Dicke form $e\Omega R/6$.

From the definition of a Kähler manifold, we see that the propagator (3) is made of a conformal metric $g_{IJ}|V|^2$ and of a Kähler metric $-D_I D^*_J|V|^2 = (D_I D^*_J K)/3 = K_{IJ}/3$.

2 – Physical discussion

Let us sum up the situation. From two independent 3-dimensional double universes OW_0 and IW_0 each one having mirror symmetry, we can build the Elementary Quantum World QW_0 in three different yet equivalent ways: whether as the tensor product (14), or the euclidian products (15) or (16). So, basically, what we need is only a 3-dimensional mirror universe appearing in three (internal or external) configuration states and we can build the single unified quantum frame containing all known fundamental interactions and matter fields. The primal interaction is quantum supergravity. In the bioquantum frame, this is nothing else than the physical display of the geometry of QW_0, as the mirror symmetry automatically induces supersymmetry between radiative and matter fields (see the proof of Proposition 3 hereabove). As for Propositions 1 and 4, they show that the scale factor exp $(-|V|^2/2)$ contracting the supergravity potentials e and e* is made of their vacuum state V (and c.c.), the amplitude of which (squared) is nothing else than a Kähler potential and therefore directly relates to chirality and (self-)polarization. So, everything can emerge from a supersymmetric quantum gravitational vacuum or Universal Vacuum, at the birth of the universe, that is, from *quantum statistical space*. Let us now turn to the fundamental interactions. Developing the base metric ds^2 on QW_0 in the objective representation (15) gives:

(18) $$ds^2 = g_{IJ}dz^I dz^{*J} = g_{iajb}dz^{ia}dz^{*jb} = g_{i-j-}dz^{i-}dz^{*j-} + g_{i0j0}dz^{i0}dz^{*j0} + g_{i+j+}dz^{i+}dz^{*j+} + \text{(coupling terms)}$$

By pure convention, we can attribute g_{i0j0} to 3-dimensional pure gravitation and g_{i-j-} to the strong interaction within the frame of Quantum ChromoDynamics (QCD). Indeed, all three principal parts in (18) have SU(3)-invariance. But this means that g_{i+j+} should stand for the electroweak interaction. Now, the GSW electroweak model has lower symmetry SU(2)xU(1). To conciliate both views, the simplest solution is to consider *two* GSW electroweak fields or, equivalently, a *complex* GSW model. We will then obtain the isomorphism $SU(3) \approx [SU(2)xU(1)]x[SU(2)xU(1)] = [SU(2)xU(1)]^2$ that we need. As there are 4 gauge bosons in the GSW model, namely W^-, W^+, Z^0 and γ, doubling it will give us 8 gauge bosons, just as required for SU(3) to be the new gauge group.

The scenario is as follows. QW_0 can be viewed as a “Yang-Yin pair”, where Yang stands for the copy filled with positive energies and Yin, the copy filled with negative energies. The mirror symmetry exchanges both copies, so that “particles” filling Yang are sent onto their “antiparticles” filling Yin and conversely. So, there can be baryon asymmetry as well as chiral-invariance violation in each copy, since Yang quite exclusively contains matter of positive energy and left-hand leptons, while Yin quite exclusively contains matter of negative energy (or “antimatter”) and right-hand “antileptons”. However, baryon symmetry as well as chiral invariance are always preserved in QW_0, thanks to the mirror symmetry. So, in QW_0, there is as many matter as there is antimatter and as many left-hand and right-hand leptons. Indeed, as the Universal Vacuum is absolutely neutral and Yang and Yin are just the mirror images of each other, attributing a definite sign to the energy of particles and to their charges is again a matter of pure convention, the physical laws being exactly the same in both Yang and Yin. So, assuming that we live in Yang, what we call “antimatter” is nothing else than matter in Yin and what we call “right-hand antileptons” are nothing else than left-hand leptons in Yin. The reason is that, in Yang, the helicity of leptons is negative, while it is positive in Yin. And this opposition simply vanishes in QW_0 where leptons have both negative and positive helicity. So, what we have is two topological transitions:

- A transition $S^8 \to S^4 x S^4$ projecting the action of $SU(3)_{EW}$ in QW_0 onto Yang and Yin. This transition, transforming the 8-sphere into a 2-S^4-torus, is physically interpreted in both Yang and Yin as spontaneous baryon symmetry and chiral invariance breaking ;
- And a transition $S^4 \to S^3 x S^1$ in each signed copy of QW_0 transforming the 4-sphere into the 2-torus $S^3 x S^1$. This last transition is physically interpreted as the spontaneous gauge symmetry breaking between the weak and electromagnetic interactions in the GSW model.

What enables the first transition is a Higgs mechanism on $|V|^2$. What enables the second transition is a Higgs mechanism on the vacuum state of the electroweak field. In all cases, transitions are made through a restructuring of a specific vacuum. But these specific vacua are actually nothing else than specified manifestations of the primal Universal Vacuum.
Finally, one remarks that a theory of pure gravitation based on the potentials e_{i0} and e^*_{i0} such that $g_{i0j0} = Tr_3(e_{i0}e^*_{j0})$, as is besides suggested in supergravity, is spin-1 and therefore renormalizable in the sense of G't Hooft. Notice in passing that this is not the case for e_I and e^*_I since a 9-dimensional vector quantity corresponds to s = 4. This is not a problem at all, as the fundamental spaces are OW_0 and IW_0, which are both 3-dimensional, and not $QW_0 = OW_0 \otimes IW_0$.

3 – The Structured Quantum World QW

We now introduce complexity in our bioquantum frame through a positive real-valued parameter l.

<u>Definition 6</u>: l is called the *complexity scale*. It is measured in meters (m).

Our central tool will be

<u>The Prigogine trick</u> [P]: Consider a collective process involving a large number of individuals or a chaotic situation involving dense sheaves of trajectories. Instead of trying to describe the dynamics of such complicated structures with statistical distributions having their support in a *deterministic frame*, it appears equivalent but much easier to describe these dynamics using *deterministic functions* taking their values in a *random frame*.

The Prigogine trick thus suggests making randomness an inherent property of the physical frame and not of dynamical systems. It is statistically equivalent to making gravitation an inherent property of the geometry of space rather than a force external to the physical frame and acting upon it. A point (z,z*) of QW_0, representing an elementary point-like object, will therefore be replaced by a probability density $\rho(z,z^*)$, representing a dense collection of elementary point-like objects and a curve z = z(u) on QW_0 will identify to the Dirac singular distribution $\delta[z-z(u)]$. As pointed out by Prigogine in [P], distributions $\rho(z,z^*)$ are regular everywhere in QW_0. A probability density $\rho(z,z^*)$ being given with support in QW_0, one can build a stochastic process:

(19) $z^I(l) = U(l).z^I$, $U(0) = 1$, $z^I(0) = z^I$ $(I = 1,\ldots,9)$

as a solution of Ito's equations with probability distribution $\rho(z,z^*)$.

<u>Definition 7</u>: The regular function U(l) is called the *evolution operator*.

In practice, the deterministic limit l = 0 will be replaced by $l = l_{min}$, the minimal complexity scale. At this scale, all processes will be considered as elementary, that is, one will assume their structure to be point-like.

<u>Definition 8</u>: A *structured process or object* [z(l),z*(l)] on the *Structured Quantum World* QW is a scale-invariant process:

(20) $\nabla z^I(l)/dl = 0$, $\nabla^* z^I(l)/dl = 0$ (and c.c.), I = 1,…,9,

where ∇ and ∇^* are the covariant derivatives on QW_0 compatible with the conformal metric (1). Equations (20) then define the *structure laws* of the process or the object [z(l),z*(l)].

The geometry of the manifold QW is then given by that of QW_0 replacing local point-like coordinates (z,z*) by local processes or objects [z(l),z*(l)] with characteristic size l (or of order l). If we are dealing with dynamical processes, their size will be the width of the largest sheaf of trajectories. In practice, l will belong to a compact interval $[l_{min}, l_{max}]$ with l_{min} non-zero and l_{max} finite. One sets:

(21) $\partial(l) = \partial/\partial z(l)$, $\partial^*(l) = \partial/\partial z^*(l)$

These vector fields are elements of the tangent bundle TQW_l , where QW_l is QW observed at the complexity scale l. Duality is done through the conformal metrical tensor:

(22a) $G_{IJ}[z(l),z^*(l)] = \exp\{-|V[z(l),z^*(l)]|^2\}.g_{IJ}[z(l),z^*(l)]$
(22b) $G^{IJ}[z(l),z^*(l)] = \exp\{|V[z(l),z^*(l)]|^2\}.g^{IJ}[z(l),z^*(l)]$
(22c) $G_{IJ}G^{JK} = g_{IJ}g^{JK} = \delta_I^K$, $G_{IJ}G^{JI} = G_{IJ}(G^{IJ})^* = g_{IJ}(g^{IJ})^* = 9$

As can be seen, thanks to the Prigogine trick, once we have the evolution law U(l) of a given process or object, all deterministic mathematics and physics can be straightforwardly applied without any change to the new structured coordinates [z(l),z*(l)]. Consequently, all the mathematical results obtained in section 1 remain valid in the structured case. Even the physics of elementary particles naturally extends without any qualitative change to objects and fields of any complexity!
Obviously, solutions of deterministic equations with variables [z(l),z*(l)] will look very different from stochastic ones with deterministic variables (z,z*) and parameter l. A simple example that well illustrates this is the wave equation in $\mathbf{R}^3$:

(23) $\Delta(l)f[\mathbf{r}(l)] = 0$, $\Delta(l) = \partial^i(l)\partial_i(l)$ (i = 1,2,3)

the solution of which is the newtonian potential $f[\mathbf{r}(l)] = 1/r(l)$. According to the Prigogine trick, (23) is equivalent to the heat equation:

(24) $(\partial/\partial l)f(\mathbf{r},l) = l.\Delta f(\mathbf{r},l)$, $\Delta = \Delta(0) = \partial^i\partial_i$ = conventional Laplacian on $\mathbf{R}^3$

the solution of which is the famous heat kernel $f(\mathbf{r},l) = l^{-3}\exp(-r^2/2l^2)$. Both kernels then have to be equivalent. This gives the relation $r(l) = l^3\exp(r^2/2l^2)$ which in turn can help determining the evolution operator U(l), as $\mathbf{r}(l) = U(l).\mathbf{r}$. One finds:

(25) $U(l) = l^3\exp(r^2/2l^2)/r = l^2\exp(r^2/2l^2)/(r/l)$

with the initial condition U(0) = 1. At large scales (high complexity), the asymptotic behaviour of U(l) is $\sim l^3/r$. So, if we set U(l) = exp[l.H(l)], then the Hamiltonian (energy operator) will be:

(26) $H(l) = r^2/2l^3 + 3(\mathrm{Ln}\ l)/l - (\mathrm{Ln}\ r)/l$

This last expression decreases with l and tends to zero at large scales, showing that the higher the complexity level (the more organized a physical system), the weaker the energy.

4 – Wave-matter duality

Let $[z^i(l),z^{*i}(l)]_{i=1,2,3}$ be a structured object on the Structured Outer World OW and $[\varphi^a(l),\varphi^{*a}(l)]_{a=-,0,+}$ a structured object on the Structured Inner World IW.

Definition 9: A structured object [φ(l),φ*(l)] of IW is called a *wavy pattern (of complexity l).*

OW and IW are dual to each other through the so-called *wave-matter duality*, which writes in the field representation:

(27) $\varphi^a[z^i(l),z^{*i}(l)] = A^a[z^i(l),z^{*i}(l)]\exp\{2i\pi S[z^i(l),z^{*i}(l)]/H(l)\}$ (a = -,0,+)

where the amplitudes A^a are of course real-valued. The function $S[z^i(l),z^{*i}(l)]$ is the “substantial” Jacobi action. It can be complex-valued, so as to include chaotic situations.

Definition 10: The function $H(l) = h - ql$, where h is Planck’s constant and q is a canonical momentum, is called the *Planck action*.

For $l = 0$, one retrieves the de Broglie wave-corpuscle duality:

(28) $\varphi^a(z^i,z^{*i}) = A^a(z^i,z^{*i})\exp[2i\pi S(z^i,z^{*i})/h]$ (a = -,0,+)

Notice that, opposite to h, which is a non-zero constant, H(l) can vanish for momenta $q = h/l$, which correspond to energies $\varepsilon = qc$. Yet, one is still quantum in a random frame, despites everything happens as if one were deterministic.

Definition 11: Physical processes satisfying $H(l) = 0$ are said to be *neo-deterministic*.

Finally, the reciprocal of the field representation $\varphi^a[z^i(l),z^{*i}(l)]$ (and c.c.) is the *internal representation* $z^i[\varphi^a(l),\varphi^{*a}(l)]$ (and c.c.). The (structured) internal variables $[\varphi^a(l),\varphi^{*a}(l)]$ are also called *hidden variables*. They can model Bohm’s *implicate order* and be used to solve the problem of the E.P.R. representation of the quantum world.

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