

## WHITEHEAD AND EURHYTHMIC BECOMING

### The Forgotten Ontology of Rhythms

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#### 1. Objectives and research motivation

The purpose of this text is to outline Whitehead's position within the philosophical debate of the 20th century, namely in relation to quantum mechanics and relativity theory. The adventure into the unknown led to the shaking of the philosophical foundations of physics, just as it had happened before with non-Euclidean geometries and with the paradoxes discovered by Bertrand Russell in his attempt to reduce the building of mathematics to logic. Whitehead has matured intellectually over, and through, these two major conceptual revisions. Its position, although peripheral, is quite unusual, and neglected<sup>1</sup>.

Whitehead aimed to melt his expertise in mathematical logic and in mathematical physics in order to get both an axiomatic and a cosmological frame different from the Newtonian: the notion of field, first introduced by electromagnetism, is not reconcilable with the mechanist image of the world<sup>2</sup>; still, both in relativity and quantum theory, non-linear phenomena have shown the limits of applicability of classical postulates<sup>3</sup>. The symbolic formalization carried on by Whitehead has as exemplifying counter-side the ontological notion of rhythm, one common to both micro- middle- and macro-scales. Despite the efforts made by many scholars<sup>4</sup>, Whitehead's realistic stance

<sup>1</sup>A negligence common to other fields of research; cfr. M. Weber, A. Weekes, *Whitehead as a neglected figure of twentieth-century philosophy*, in M. Weber & A. Weekes (Eds.), *Process approaches to consciousness in psychology, neuroscience, and philosophy of mind*, State University of New York Press, Albany, NY, 2009, pp. 57-72.

<sup>2</sup> Cfr. J. C. Maxwell, *A Dynamical Theory of the Electromagnetic Field*, in W. D. Niven (Eds.), *The Scientific Papers of James Clerk Maxwell (1890)*, Dover Publications, New York, 1965, pp. 526-597; J. J. Thomson, *On the Illustration of the Properties of the Electric Field by Means of Tubes of Electrostatic Induction*, in «Philosophical Magazine», 31, 1891, pp. 149-171; H. Hesse, *Forces and Fields. The Concept of Action at a Distance in the History of Physics*, Dover Publications, New York, (1961) 2005; J. Agassi, *Faraday as a Natural Philosopher*, The University of Chicago Press, Chicago & London, 1971; W. Berkson, *Fields of Forces. The Development of a World View from Faraday to Einstein*, Routledge, London e New York, (1974) 2014; D. Gooding, *Faraday, Thomson, and the Concept of Magnetic Field*, in «The British Journal for the History of Science», 13, 1980, pp. 91-120; R. A. Brooks, *Fields of Color: the theory that escaped Einstein*, Universal Printing, LLC Silver Spring, Maryland, (2010) 2016.

<sup>3</sup> Cfr. J. R. Croca, *Hyperphysics - The Unification of Physics*, in J. R. Croca, J. E. F. Araujo, (Eds.), *A New Vision of Physics. Eurhythmy, Emergence and Nonlinearity*, Center for Philosophy of Science, University of Lisbon, Lisbon, 2010; R. N. Moreira, *The Crisis in Theoretical Physics. Science, Philosophy and Metaphysics*, in J.R. Croca, J.E.F. Araújo (eds.), *A New Vision on PHYSIS. Eurhythmy, Emergence and Nonlinearity*, Center for Philosophy of Science, University of Lisbon 2010, pp. 255-312.

<sup>4</sup> Cfr. M. Čapek, *The New Aspects of Time. Its Continuity and Novelities. Selected Papers in the Philosophy of Science*, Kluwer Academic Publishers, Dordrecht, 1991, p. 221; S. Malin, *Whitehead's Philosophy and the Collapse of Quantum States*, in T. E. Eastman, H. Keaton (Eds.), *Physics and Whitehead. Quantum, Process, and Experience*, State University of New York Press, Albany, NY, 2003, pp. 74-83; H. P. Sapp, *Whiteheadian Process and Quantum Theory*, in T. E. Eastman, H. Keaton (Eds.), *Physics and Whitehead. Quantum, Process, and Experience*, State University of New York Press, Albany, NY, 2003, pp. 92-102; Y. Tanaka, *The individuality of a Quantum Event: Whitehead's Epochal Theory of Time and Bohr's Framework of Complementarity*, in T. E. Eastman, H. Keaton

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invalidates any attempt to relate his philosophy to either the Copenhagen's and the orthodox interpretation of quantum mechanics. My aim is to show that what is missing in the latter, and is instead the very heart of the former, is an ontology.

## 2. Mathematical logics as *organon* for philosophical speculation

Between the logic-mathematical and the later philosophical means employed by Whitehead there exists a deep continuity. This continuity is rooted in Whitehead's specific understanding of mathematics as an instrument for natural science, namely, into his stretching mathematical symbolism towards a rendering of natural becoming<sup>5</sup>.

Mathematics is understood by Whitehead and it serves him as an Ariadne's line, which may help in seeking the symbolic expression for the existence of change in nature, and which may indicate an exit from the labyrinth of the traditional mechanistic axiomatic of physics. According to Whitehead, his «work had its origin in the study of mathematical theory of Electromagnetism, and had as its ultimate aim the general scrutiny of the relation of matter and space»<sup>6</sup>. The continuity between his «scheme of work» and «general aim» as mathematical physicist and his philosophical development is shown in the following quote from *An Enquiry Concerning the Principles of Natural Knowledge* (PNK, 1919):

The contributions of mathematics to natural science consist in the elaboration of the general art of deductive reasoning, the theory of quantitative measurement by the use of number, the theory of serial order, of geometry, of the exact measurement of time, and of rates of change. The critical studies of the nineteenth century and after have thrown light on the nature of mathematics and in particular on the foundations of geometry. We now know many alternative sets of axioms from which geometry can be deduced by the strictest deductive reasoning. But these investigations concern geometry as an abstract science deduced from hypothetical premisses. In this enquiry we are concerned with geometry as a physical science<sup>7</sup>.

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(Eds.), *Physics and Whitehead. Quantum, Process, and Experience*, State University of New York Press, Albany, NY, 2003, pp. 164-79.

<sup>5</sup> Whitehead has a very original conception of mathematics also in regard to education and to the natural, rhythmical becoming of pupils' growth: cfr. H. Woodhouse, *Mathematics as liberal education: Whitehead and the rhythm of life*, «Interchange», 43(1), 2012, pp. 1-23. The pupils' rhythmical growth that education have to assist is described especially in the essays *The Rhythm of Education* (1922) and *The Rhythmic Claims of Freedom and Discipline*, in A. N. Whitehead, *The Aims of Educations and other Essays*, The Free Press, New York, 1967 (1929), pp. 24-44 and 45-65. In the present work I will not refer to Whitehead's philosophy of education and its rhythmical features because this subject needs a careful scrutiny for which there is no room here.

<sup>6</sup> V. Lowe, *Alfred North Whitehead: The Man and His Work, Volume I: 1861-1910*, The John Hopkins University Press, Baltimore, 1985, pp. 155-56.

<sup>7</sup> A. N. Whitehead, *An Inquiry Concerning the Principles of Natural Knowledge*, Cambridge University Press, London, 1919, p. v.

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What does it mean to be concerned with «geometry as a physical science»? It seems to me that what differentiates the common understanding of mathematics in general (and geometry in particular) as an abstract science from Whitehead's own is the «theory of rates of change». It is this contribution to natural science that has gone unnoticed for the majority of thinkers until now. It is this point that the present work will try to explore.

### 3. *Pars destruens* and *pars construens* in Whitehead's thought

For Whitehead, the «traditional scientific concepts» are untenable:

The governing principle underlying this scheme is that extension, namely extension in time or extension in space, expresses disconnection. This principle issues in the assumptions that causal action between entities separated in time or in space is impossible and that extension in space and unity of being are inconsistent<sup>8</sup>.

Now, as an achievement of his *Treatise of Universal Algebra*, and contrary to the governing principle guiding traditional theories, Whitehead has grasped that the possibility for the mathematical treatment of physical intensities is grounded on the reduction of concepts and propositions to their extension. It is on this ground that the basic aim of rational thought, that is, to give a coherent account of experience, can be pursued. Hence, Whitehead inverts one fundamental assumption underlying the mechanist ontology. The latter, postulating durationless instants of time, is not able to deal with the more basic feature of our experience, i.e. that «something is going on». Then, the fact that nature manifests itself as always «moving on» is the starting point for natural philosophy.

We must therefore in the ultimate fact, beyond which science ceases to analyse, include the notion of a state of change. But a state of change at a durationless instant is a very difficult conception. It is impossible to define velocity without some reference to the past and the future. Thus change is essentially the importation of the past and of the future into the immediate fact embodied in the durationless present instant<sup>9</sup> [1919:2].

The first complementary side of Whitehead's *pars destruens* of the substantialist ontology of scientific mechanicism – its first *pars construens* – is «the notion of a state of change», that is, that the mathematical «theory of rates of change» has to be able to substitute the notion of 'instant' with that of «lapse of time»:

According to ordinary physics, the perceptions resulting from changing relations between physical objects occur during a certain lapse of

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<sup>8</sup> *Ivi*, p. 1.

<sup>9</sup> *Ivi*, p. 2.

time<sup>10</sup>.

However, Whitehead continues, if we maintain as a fundamental propriety the spatial separation and disconnection between natural ultimate entities then we cannot explain causation. If the causal action between two entities is the transmission of stress between them, we cannot assume either that this transmission occurs among points, since «no two points are in contact», or that it occurs among «infinitely small volumes», since «it cannot be meant that the surface acts on the interior»<sup>11</sup>. By developing the results of his memoir, *On The Mathematical Concept of the Material World*, Whitehead showed the inadequacies of and inconsistencies resting on the fundamental ontological postulate of mechanist axiomatics. If in both Newton's mechanics and Einstein's relativity time had been spatialised, what Whitehead intends to do it is to temporalise the space (as well as the relativistic space-time).

The next step he made was to appeal to the fact that the concept of organism implies a functioning during a period of time:

[...] in biology the concept of an organism cannot be expressed in terms of a material distribution at an instant. The essence of an organism is that it is one thing which functions and is spread through space. Now functioning takes time. Thus a biological organism is a unity with a spatio-temporal extension which is of the essence of its being<sup>12</sup>.

Nevertheless, to avoid misunderstanding, it is important to note that this does not mean that biological phenomena «belong to a different category to other physical phenomena». In fact, a careful examination of what has been observed through the advancement of physics and technology leads to the same conclusions which could be derivable from biological sciences or from perceptive experience, namely that the ultimate entities the world is build by are events:

The modern theory of the molecule is destructive of the obviousness of the prejudgment in favour of the traditional concepts of ultimate material at an instant. Consider a molecule of iron. [...] No single characteristic property of iron as such can be manifested at an instant. Instantaneously there is simply a distribution of electricity and Maxwell's equations to express our expectations. But iron is not an expectation or even a recollection. It is a fact; and this fact, which is iron, is what happens during a period of time. Iron and a biological organism are on a level in requiring time for functioning. There is no such thing as iron at an instant; to be iron is a character of an event. Every physical constant respecting iron which appears in scientific tables is the register of such a character. What is ultimate in iron,

<sup>10</sup> Id., *La théorie relationniste de l'espace* (1914), cit. in H. Keeton, *Whitehead as Mathematical Physicist*, in T. E. Eastman, H. Keeton, (Eds.), *Physics and Whitehead; Quantum, Process, and Experience*, State University of New York Press, Albany (NY), 2003, pp. 31-46, p. 33

<sup>11</sup> A. N. Whitehead, *An Inquiry Concerning the Principles of Natural Knowledge*, cit., pp. 2-3.

<sup>12</sup> Ivi, p. 3.

according to the traditional theory, is instantaneous distributions of electricity; and this ultimateness is simply ascribed by reason of a metaphysical theory, and by no reason of observation<sup>13</sup>.

Even if at this phase of his adventures of ideas Whitehead had not explicitly established the cosmological equivalence between the notion of «event» and that of «organism», some strong similarity had been glimpsed: both events and organism need time for functioning and then to exist as such. The substantialist metaphysics postulating the undifferentiated permanence of ultimate entities springs from the «bifurcation of nature». What is a mere «method of procedure necessary for the finite expression of individual propositions»<sup>14</sup>, something arising from our contingent and limited linguistic means, in some way inverts the concrete situation presented in perceptive awareness:

[...] the termini for thought are entities, primarily with bare individuality, secondarily with properties and relations ascribed to them in the procedure of thought; the termini for sense-awareness are factors in the fact of nature, primarily related and only secondarily discriminated as distinct individualities<sup>15</sup>.

Thus, according to Whitehead, it is not only an inappropriate generalization based on the middle-size physical objects of common experience, a generalization which several thinkers believe to have putative adaptive evolutionary origins<sup>16</sup>, but it is also just a cultural, contingent and arbitrary one, and it can and must be overcome. It is easy to see that Whitehead's endeavour went in the opposite direction of that followed by Bohr with his doctrine of the indispensability of the classical concepts, a doctrine on which the complementarity principle is rooted<sup>17</sup>.

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<sup>13</sup> Ivi, pp. 22-3.

<sup>14</sup> A.N. Whitehead, *The Concept of Nature*, Cambridge University Press, London, 1920, p. 12.

<sup>15</sup> Ivi, pp. 12-3.

<sup>16</sup> During the nineteenth and twentieth centuries many philosophers and scientists tried to render the Kantian «synthetic *a priori* judgments» as a static, insurmountable result of our evolutionary adaptation. Among the thinkers that have translated transcendental idealism into an evolutionary positivist perspective we can mention H. Spencer, H. von Helmholtz, E. Mach, H. Poincaré, N. Bohr, W. Heisenberg, M. Cipek, H. Reichenbach, and K. Lorentz. Nevertheless, as shown by Whitehead's work, it is not the case. Our middle-size dimension of experience doesn't imply either a substantialist ontology of the ultimate natural entities or an understanding of time-space as mathematical continua. They are simply the result of the contingent historical path Western science and philosophy have taken. Indeed, different epistemologies and ontologies have been elaborated by other cultures.

<sup>17</sup> N. Bohr, *The Quantum Postulate and the Recent Development of Atomic Theory* (1927), in J. Kalckar (Ed.), *Niels Bohr Collected Works, Vol. 6: Foundations of Quantum Physics I (1926-1932)*, North-Holland, Amsterdam 1985, pp. 109-146; Id., *The Atomic Theory and The Fundamental Principles Underlying The Description of Nature* (1929), in J. Kalckar (Ed.), *N. Bohr Collected Works, Vol. 6*, 1985, pp. 236-253; Id., *Introductory Survey (with addendum of 1931) to The Atomic Theory and the Description of Nature* (1929), in J. Kalckar (Ed.), *Niels Bohr Collected Works, Vol. 6: Foundations of Quantum Physics I (1926-1932)*, North-Holland, Amsterdam 1985, pp. 255-302.

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#### 4. The reconciliation of common experience with scientific knowledge

Further, it is naive to ascribe the acknowledgement of this inadequacy to the advent of quantum theory, since this inadequacy was anticipated by the philosophers W. James, C. S. Pierce and Bergson<sup>18</sup>. Indeed, it concerns also our ordinary, middle-size experience, as can be shown by taking in consideration musical phenomena, since a musical note is as much a natural entity as a stone is, but one with very different characteristics:

For example a musical note cannot exist in a period of time shorter than its period of vibration, and a percipient whose specious present was too short could not hear it<sup>19</sup>.

Instants, points and corpuscles show their fictional theoretic nature when we try to use them as cognitive tools to describe ordinary physical phenomena as well as biological phenomena:

Life (as known to us) involves the completion of rhythmic parts within the life-bearing event which exhibits that object. We can diminish the time-parts, and, if the rhythms be unbroken, still discover the same object of life in the curtailed event. But if the diminution of the duration be carried to the extent of breaking the rhythm, the life-bearing object is no longer to be found as a quality of the slice of the original event cut off within that duration. This is no special peculiarity of life. It is equally true of a molecule of iron or of a musical phrase. Thus there is no such thing as life 'at one instant'; life is too obstinately concrete to be located in an extensive element of an instantaneous space<sup>20</sup>.

One is led to the conclusion that the mathematical continuity, i.e. the infinite divisibility, is not an adequate means by which to explain concrete experience. The rhythmical nature of concrete phenomena prevents us from considering an instantaneous space at a durationless instant as an appropriate rendering of perceived facts. In this sense, one does not have to resort to either the theory of relativity or to quantum theory for philosophical scrutiny of our linguistic and conceptual conventions. Following a methodological consistency throughout his investigations, namely continuing to use symbolic logic as the basis for his arguments (only occasionally supported by concrete exemplification), Whitehead developed the formalization of the method of extensive abstraction, which is derived directly from the fundamental axioms of extension according to which any «event extends over» other events:

Every element of space or of time (as conceived in science) is an abstract entity formed out of this relation of extension (in association

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<sup>18</sup> Max Jammer rightly contended «that certain philosophical ideas of the late nineteenth century not only prepared the intellectual climate for, but contributed decisively to, the formation of the new conceptions of the modern quantum theory»; cfr. M. Jammer, *The Conceptual Development of Quantum Mechanics*, McGraw-Hill, New York, 1966, pp. 166-67.

<sup>19</sup> A. N. Whitehead, *An Inquiry Concerning the Principles of Natural Knowledge*, cit., p. 168.

<sup>20</sup> Ivi, p. 196.

at certain stages with the relation of cogredience) by means of a determinate logical procedure (the method of extensive abstraction). The importance of this procedure depends on certain properties of extension which are laws of nature depending on empirical verification. There is, so far as I know, no reason why they should be so, except that they are. [...] It is a method which in its sphere achieves the same object as does the differential calculus in the region of numerical calculation, namely it converts a process of approximation into an instrument of exact thought. The method is merely the systematisation of the instinctive procedure of habitual experience. The approximate procedure of ordinary life is to seek simplicity of relations among events by the consideration of events sufficiently restricted in extension both as to space and as to time; the events are then 'small enough'<sup>21</sup>.

Via his logical exactitude and methodological awareness Whitehead showed that notions commonly deemed as being primitive are derivative abstract constructs of a thought process acting on perception. The latter is defined as «an awareness of events, or happenings, forming a partially discerned complex within the background of a simultaneous whole of nature»<sup>22</sup>. As we can see, the specific tone of Whitehead's realism consists in the fact that the rational construction must be a loyal account and a generalization of perceptive awareness. If the latter manifests to us nature as a systematic tissue of events going on, then it follows that a reformulation of the traditional meaning that both classical science and vulgar usage attribute to the word 'object' is needed. In Whitehead's terminology and conceptualization, an 'object' is defined as a class of relations between events:

An object is a characteristic of an event. Such an object may be in fact a multiple relation between objects situated in various parts of the whole event. In this case the quality of the whole is the relationship between its parts, and the relation between the parts is the quality of the whole. The whole event being what it is, its parts have thereby certain defined relations; and the parts having all the relations which they do have, it follows that the whole event is what it is. The whole is explained by a full knowledge of the parts as situations of objects, and the parts by a full knowledge of the whole. Such an object is a pattern<sup>23</sup>.

An object is a pattern. An object is a relational concept, a qualitative one. An object is a structural and permanent factor within the flux of events. It is an abstract entity – a theoretical one – although it is also a characteristic of external events. Indeed, against nominalist philosophers, Whitehead's constructivism is a sophisticated form of realism, a relational eidetic realism, similar to that of Duns Scotus or C. S. Pierce<sup>24</sup>. The objective factors of

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<sup>21</sup> Ivi, pp. 75 e 76.

<sup>22</sup> Ivi, p. 68.

<sup>23</sup> Ivi, p. 195.

<sup>24</sup> Whitehead's philosophy of mathematics was rightly called “process structural realism”; cfr. J. E. Earley Sr., *Ontologically Significant Aggregation: Process Structural Realism*, in M. Weber, W. Nóema, 11 (2020): *Processo e realtà: sull'attualità di Whitehead*

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nature are nothing but relationships, as explained in Whitehead's *UA* and *MC*. And these relatednesses do not have as their relata the substantialised ultimate entities commonly referred to as particles of matter. Further, the latter is nothing but a derivative concept. At this point we can see the depth of Whitehead's philosophical difference from Einstein's relativity theory<sup>25</sup>:

[We] shall employ the term 'ether of events' to express the assumption of this enquiry, which may be loosely stated as being 'that something is going on everywhere and always'. It is our purpose to express accurately the relations between these events so far as they are disclosed by our perceptual experience, and in particular to consider those relations from which the essential concepts of Time, Space, and persistent material are derived. Thus primarily we must not conceive of events as in a given Time, a given Space, and consisting of changes in given persistent material. Time, Space, and Material are adjuncts of events. On the old theory of relativity, Time and Space are relations between materials; on our theory they are relations between events<sup>26</sup>.

Everlastingly, nature advances. This is the starting point for rational thought. Our awareness of the existence of change is what classical science has been unfaithful to. But our idealized science cannot withhold these qualitative features. Within the becoming of repetitive structural patterns, differences are generated, novelty emerges, meta-stable asymmetries keep the flux far away from the silent noise of an absolute order. Temporary coherence emerges. Relative order is achieved. For, a mathematical science of nature must concern itself with rates of change. These rates are rhythmical. Nature pulses. Only ten years later, in *Process and Reality (PR)*, Whitehead will say that the universe is an organism, and only twenty years later, in *Modes of Thought (MT)*, he will say that nature is alive. But already in 1919 he was aware that among the middle-size perceived phenomena we should not generalize from mineralogical rigid physical objects a metaphor for nature. Nature's ultimate entities are not like little stones. Nature is not a mechanism. A machine is an artefact; it needs an external agency to come to existence. Mechanist philosophy and scientific materialism had been a necessary compromise in the fight for cultural hegemony in the fundamentalist theological epoch in which they were born. Mechanistic theory was also a political agreement. But we should stop to think through this nefarious reductionist analogy. We should begin to consider nature as an autopoietic, developing organism. We should care about natural rhythms, since «Life is the rhythm as such, whereas a physical object is an average of rhythms which build no rhythm in their aggregation; and thus

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Desmond, (Eds.), *Handbook of Whiteheadian Process Thought*, Vol. 2, Ontos Verlag, Frankfurt, 2008, pp. 179-192.

<sup>25</sup> R. Desmet, *How Did Whitehead Become Einstein's Antagonist? On Poincaré and Whitehead*, in «Process Studies», 37, Issue 2, 2008, pp. 5-23; Id., *The Minkowskian Background of Whitehead's Theory of Gravitation*, in V. Petkov, *Space, Time, and Space-Time. Fundamental Theories of Physics*, Springer Verlag, Berlin 2010, pp. 255-312; Id., *On the Need to Interpret General Relativity*, in «Process Studies Supplement», Issue 15, 2010, pp. 1-65; Id., *Putting Whitehead's Theory of Gravitation in Its Historical Context*, in «Logique & Analyse», 214, 2011, pp. 287-315.

<sup>26</sup> A. N. Whitehead, *An Inquiry Concerning the Principles of Natural Knowledge*, cit., pp. 25-6.

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matter is in itself lifeless»<sup>27</sup>. The apparent uniformity of physical objects has to be considered as an average property within a more complex and unstable rhythmical relationship. The last pages of Whitehead's inquiry contain a fundamental clarification of his thought, so we need to quote extensively:

Furthermore in the physical object we have in a sense lost the rhythms in the macroscopic aggregate which is the final causal character. But life preserves its expression of rhythm and its sensitiveness to rhythm. [...] It exhibits variations of grade, higher and lower, such that the higher grade presupposes the lower for its very existence. This suggests a closer identification of rhythm as the causal counterpart of life; namely, that wherever there is some rhythm, there is some life, only perceptible to us when the analogies are sufficiently close. The rhythm is then the life, in the sense in which it can be said to be included within nature. Now a rhythm is recognizable and is so far an object. But it is more than an object; for it is an object formed of other objects interwoven upon the background of essential change. A rhythm involves a pattern and to that extent is always self-identical. But no rhythm can be a mere pattern; for the rhythmic quality depends equally upon the differences involved in each exhibition of the pattern. The essence of rhythm is the fusion of sameness and novelty; so that the whole never loses the essential unity of the pattern, while the parts exhibit the contrast arising from the novelty of their detail.

[...] every great rhythm presupposes lesser rhythms without which it could not be. No rhythm can be founded upon mere confusion or mere sameness. An event, considered as gaining its unity from the continuity of extension and its unique novelty from its inherent character of 'passage' contributes one factor to life; and the pattern exhibited within the event, which as self-identical should be a rigid recurrence, contributes the other factor to life. A rhythm is too concrete to be truly an object. It refuses to be disengaged from the event in the form of a true object which would be mere pattern. What the pattern does do is to impress its atomic character on a certain whole event which, as one whole bearing its atomic pattern, is a unique type of natural element, neither a mere event nor a mere object as object is here defined. This atomic character does not imply a discontinuous existence for a rhythm; thus a wave-length as marked out in various positions along a train of waves exhibits the whole rhythm of the train at each position of its continuous travel. The very fact of a non-uniform object involves some rhythm.

[...] Solar systems and star clusters exhibit rhythm of a simplicity analogous to that of molecules. It is impossible not to suspect that the gain in apparent complexity at the stage of our own rhythm bearing events is due rather to our angle of vision than to any inherent fact of nature. There are also stray rhythms which pass over the face of nature utilising physical objects as mere transient vehicles for their expression. [...] But the subtlety of rhythm appears to require a certain stability of

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<sup>27</sup> Ivi, p. 197.

material. Thus the permanence of the individual rhythm within nature is not absolutely associated with one definite set of material objects. But the connection for subtler rhythms is very close.<sup>28</sup>

### 5. The ontological reunification of the world

Now, remembering Whitehead's conceptualization of the notion of «equivalence», in *UA*, also termed «equality» in *The Principle of Relativity, with Applications*, as an identity in diversity, we contend that the concept of «rhythm» is one with a most general character. Since, «in the philosophy of science we seek the general notions which apply to nature, namely, to what we are aware of in perception»<sup>29</sup>, then the notion of rhythm is a good candidate to work with. In a sense it could be applicable to everything, by modulating it depending on the scale concerned. Regardless of whether we are describing a micro-, middle- or macro-scale, we can find the rhythmical feature of existence everywhere. We can conceive of this concept as a *scalable*, or fractal one, meaning that the general principles apply throughout different levels of analysis. Furthermore, it is pre-eminent for individuating the similarities and dissimilarities among phenomena. Thus, in a sense it is the *principium individuationis* that determines the nature of any entity<sup>30</sup>. Via this concept, philosophy of science and philosophy of nature may be reconciled after the positivist proclamations of their divorce. Rhythms, as the «causal counterpart of life» and with their «fusion of sameness and novelty», can be deemed as sharing and anticipating the actual occasions of the later organicist cosmology; in fact the first «Categories of Existence» of *Process and Reality*, like rhythm, «combines self-identity with self-diversity»<sup>31</sup>. Additionally, the concept of society of actual occasions has its basis in that of rhythms. Notwithstanding, it is urgent to avoid misunderstanding by distinguishing the concept of rhythm from the technical physical concept of vibration, even if the latter could be an abstract approximation of the former. Indeed, we must avoid the «fallacy of the misplaced concreteness», reducing the concrete complexity of natural entities to their abstract mathematical characteristic:

For example - Whitehead said - the wave-theory of light is an excellent well-established theory; but unfortunately it leaves out colour as perceived. [...] In other words this concept of the fundamental relations within nature is inadequate<sup>32</sup>.

<sup>28</sup> Ivi, pp. 196-200.

<sup>29</sup> A. N. Whitehead, *The Concept of Nature*, cit., p. 28.

<sup>30</sup> «We are interested in equality because diversity has crept in. In fact a discussion of equality embraces in its scope congruence, quantity, measurement, identity and diversity. [...] The relation of equality denotes a possible diversity of things related but an identity of character qualifying them»; Id., *The Principle of Relativity, with Applications*, Cambridge University Press, London, 1922, pp. 41-42. If on one hand, Mays considers the concept of equivalence as worked by Whitehead a refinement of Leibniz's principle of indiscernibles (cfr., W. Mays, *Whitehead and the Idea of Equivalence*, «Rev. Int. de Phil.», 56-57, 1961, pp. 167-84, p. 173); on the other hand Couturat finds in it the echoes of Platonic logic and metaphysics (cfr. L. Couturat, *L'Algèbre Universelle de M. Whitehead*, «Rev. de Mét. et de Morale», VIII, 1900, pp. 323-362, p. 325).

<sup>31</sup> Id., *Process and Reality; An Essay in Cosmology*, The Free Press, New York, 1978, pp. 22 e 25.

<sup>32</sup> Id., *The Concept of Nature*, cit., pp. 46-7.

We must also not fall into the «fallacy of bifurcation», which « modern natural philosophy is shot through and through with»<sup>33</sup>. It is necessary to escape from any kind of reductionism, especially the Pythagorean and the Newtonian ones, which are the most insidious. Mathematical and material properties are nothing but some of the factors of the determinedness of events. They could perhaps be enough for some specialized science, but not for philosophy. Relying on them, important elements of our experience are always missing: life, sentience, desire, emotion, feeling, will, valuation, meaning, enjoyment, expectation, colours, sound, smell, importance, expression, cognition, value, contingency, transgression, freedom, novelty. This is a great challenge for our civilization, shaped by monist Judaic-Christian theology on one side, and by Parmenides's monist epistemology on the other. To overcome the historical limits of Western civilization we have to repudiate the bifurcation into two separated substances (Descartes's dualism), and into a «real» and an «apparent» nature. According to Whitehead,

[the] problem is to discuss the relations *inter se* of things known, abstracted from the bare fact that they are known. Natural philosophy should never ask, what is in the mind and what is in nature. To do so is a confession that it has failed to express relations between things perceptively known, namely to express those natural relations whose expression is natural philosophy<sup>34</sup>.

Both the ancient Greek and the modern scientific ideas of matter as a substance are due to:

[...] one long misconception of the metaphysical status of natural entities. The entity has been separated from the factor which is the terminus of sense-awareness. It has become the substratum for that factor, and the factor has been degraded into an attribute of the entity. In this way a distinction has been imported into nature which is in truth no distinction at all. A natural entity is merely a factor of fact, considered in itself. Its disconnection from the complex of fact is a mere abstraction. It is not the substratum of the factor, but the very factor itself as bared in thought<sup>35</sup>.

What Whitehead intends to do, continuing his logic-mathematical work by philosophical means, is to shape a dynamic and relational ontology. According to him, the existence of «objects» is given to us within our non-intellectual experience, i.e. it is a data and a condition for «sense-recognition» «which connects the mind with a factor of nature without passage»<sup>36</sup>. Since recognition is awareness of sameness, and since the streaming events differ from each other, the objects are the factors or the «ingredient» within the events which characterize them as equivalent:

<sup>33</sup> Ivi, p. vi.

<sup>34</sup> Ivi, p. 30.

<sup>35</sup> Ivi, p. 16.

<sup>36</sup> Ivi, p. 143.

Thus the theory of objects is the theory of the comparison of events. Events are only comparable because they body forth permanences. We are comparing objects in events whenever we can say, 'There it is again'. Objects are the elements in nature which can 'be again'<sup>37</sup>.

Now, remembering from *PNK* that the «fundamental relation of extension» states that any event «extend over» other events<sup>38</sup>, we recall that objects also extend over each other:

An object is ingredient throughout its neighbourhood, and its neighbourhood is indefinite. Also the modification of events by ingression is susceptible of quantitative differences. Finally therefore we are driven to admit that each object is in some sense ingredient throughout nature; though its ingression may be quantitatively irrelevant in the expression of our individual experiences<sup>39</sup>.

The theories of the «eternal objects' realm», of the «extensive continuum» and of «prehensions» are close. The «constructive task» begun in *UA* and *MC* conduced Whitehead to glimpse that within the «passage of nature» the extendedness and interconnectedness of events has to be interpreted as exhibiting more stable elements. Maintaining «the humbler thesis that nature is a system»<sup>40</sup> means that «nature is such that there can be no events and no objects without the ingression of objects into events»<sup>41</sup>. His latest doctrine of the «mutual immanence» of facts and forms was already anticipated in 1920. If «an object is in a sense out of time», being «derivatively in time by reason of its having the relation to events which I term 'situation'»<sup>42</sup>, its existence begins to be understood by Whitehead as ubiquitous potentiality, a kind of existence different from that of the time-space series of events. Once more, it is important to emphasize that Whitehead did not reduce «objects» to either mathematical figures or mathematical potentiality. In this sense his vision radically differs from that of Heisenberg, who in various moment seems to suggest a Pythagorean reductionism<sup>43</sup>. Whitehead's thematization of «potentiality» was much richer and not reducible nor comparable to the wave function issues of quantum mechanics. Indeed, Whitehead arrived to his conclusions before quantum mechanics had become the orthodox interpretation of quantum theory. Basically, as any element in his biography or

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<sup>37</sup> Ivi, p. 144.

<sup>38</sup> Id., *An Inquiry Concerning the Principles of Natural Knowledge*, cit., p. 101.

<sup>39</sup> Id., *The Concept of Nature*, cit., p. 145.

<sup>40</sup> Ivi, p. 146.

<sup>41</sup> Ivi, p. 144.

<sup>42</sup> Ivi, p. 78.

<sup>43</sup> W. Heisenberg, *Physics and Philosophy. The Revolution in Modern Science*, Allen and Unwin Edition, London, 1971 (1959), pp. 68-9, 76 e 83. In this sense I do not agree with those who think – like Northrop in his *Introduction to Heisenberg's Physics and Philosophy* – that «Heisenberg's philosophy of physics has an element in common with that of Whitehead»; in Ivi, p. 14. As had been showed, Whitehead was aware of and respond to the «challenge of Pythagoreanism»; cfr. A. Gare, *Whitehead and Pythagoras*, in «Concrescence: The Australian Journal of Process Thought», Vol. 7, 2006, pp. 3-19.

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bibliography seems to indicate, the physics theory that inspired his philosophical path toward the repudiation of material entities' «simple location» was electromagnetism<sup>44</sup>:

As long ago as 1847 Faraday in a paper in the *Philosophical Magazine* remarked that his theory of tubes of force implies that in a sense an electric charge is everywhere. The modification of the electromagnetic field at every point of space at each instant owing to the past history of each electron is another way of stating the same fact<sup>45</sup>.

If each event extends orderly over the others, and if each event is the situation for objects, then consequently the structural factors of experience, the objects, also have a «relational essence»:

An eternal object, considered as an abstract entity, cannot be divorced from its reference to other eternal objects, and from its reference to actuality generally; though it is disconnected from its actual modes of 'ingression' into definite actual occasions<sup>46</sup>.

Against epistemological atomism Whitehead rejected the simplicity of our sense-data, which for him are always complex, and when analyzed still exhibit complex components. As he said, «Exactness is an ideal of thought, and is only realised in experience by the selection of a route of approximation»<sup>47</sup>.

## 6. Developing Faraday's scientific investigation program

In his book from the 1920, Whitehead still spoke about the «event-particle» as the tiniest physical entity that the methodical symbolic route of approximation can obtain. Continuing to derive and explain scientific notions on a logical ground, he began with a logical discussion of the notion of «equality» that he believed to be founded on the direct perception of «matching» between properties, either of length or of colours. The logical scrutiny of such commonly utilized notions allowed Whitehead to state that space-time relations have to be grounded in a uniform structure:

We have got to dismiss from our minds all considerations of number and measurement and quantity, and simply concentrate attention on what we mean by matching in length. [...] Our physical space therefore must already have a structure and the matching must refer to some qualifying class of qualities inherent in this structure<sup>48</sup>.

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<sup>44</sup> Cfr. H. Keeton, *Whitehead as a Mathematical Physicist*, in Timothy E. Eastman, Hank Keeton (Eds.), *Physics and Whitehead. Quantum, Process, and Experience*, SUNY Press, New York 2003, pp. 31-46; R. Desmet, *Whitehead's Cambridge Training*, in R. Desmet, M. Weber, (Eds.), *Whitehead. The Algebra of Metaphysics*, Les Éditions Chromatika, Louvain-la-Neuve (Belgica), 2010, pp. 91-125.

<sup>45</sup> A. N. Whitehead, *The Concept of Nature*, cit., p. 146.

<sup>46</sup> Id., *Science and Modern World*, The Macmillan Company, New York, 1948 (1925), p. 160.

<sup>47</sup> Id., *The Concept of Nature*, cit., p. 59.

<sup>48</sup> Id., *The Principle of Relativity*, cit., p. 51.

On this foundational ground he rejected the possibility of logically understanding the meaning of Einstein's theory about the curvature of the space-time continuum. After having defined time and space as properties of events, then sharing with them their extensiveness<sup>49</sup>, Whitehead explained that the notion of «physical field», either gravitational or electromagnetic, represents the immanent influence of the past historical route of the event-particle on the present and future situation of its route:

The physical field is merely that character of nature which expresses the relatedness between the apparent adjectives of the past and the apparent adjectives of the future. It therefore shares in the contingency of appearance, and accordingly can not affect spatial-temporal relations [1922:72].

The difference between Einstein's and Whitehead's theories is that the former ascribed to space-time a curving character which the latter ascribed to the physical field only. In this way, according to Whitehead, it is possible to avoid the circularity of Einstein's definition of measurement – where the measure is deemed as dependent upon the contingent physical object which qualities (eg. the length) the measure is supposed to determine, and which before the measurement operation are obviously unknowable. Both the immanence of the past that the field expresses and the events' inherent adjectives that a measure has to determine, if we applied these concepts to quantum theory issues, could show how Whitehead's thought is difficult to assimilate into the Copenhagen interpretation of quantum mechanics. But if on the one hand the physical field expresses according to Whitehead the causal connectedness of events, on the other hand it also expresses their atomic localization in the system of nature:

Luckily the physical field is atomic, so far as concerns our approximate measurements. By this I mean that we can discriminate in the four-dimensional continuum certain regions or events, such that each exhibits a physical character which is entirely independent of the physical characters of other events or of the other physical characters of that event. This physical character requires the whole region for its complete exposition. Thus atomicity implies two properties, one is the breakdown of relativity in that the atomic character is independent of the physical characters pervading the rest of nature, and the other is that we cannot completely exhibit this character without the whole corresponding region. [...] Furthermore, atomicity is a property which is capable of more or less complete realisation. Failure to attain complete atomicity is illustrated when one aspect of the physical field modifies

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<sup>49</sup> «The homogeneity of time with space arises from their common share in the more fundamental quality of extension which is a quality belonging exclusively to events. By extension I mean that quality in virtue of which one event may be part of another or two events may have a common part. Nature is a continuum of events so that any two events are both parts of some larger event»; Ivi, p. 67.

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another aspect of it, for example, when the physical field of mass modifies that of electromagnetism<sup>50</sup>.

Thus, for Whitehead, causation and localization are not exclusive components of the ultimate physical entities' description, as Bohr repeatedly claimed. Each field is an extended region where the passage of nature can ideally be arrested without having to be concerned, to some practical extent, with its time-system relativity:

In so far as nature is systematically related, it is a system of uniform relatedness; and in the second place, intelligibility is preserved amid the contingency of appearance by the breakdown of relatedness which is involved in atomicity<sup>51</sup>.

The following important step of Whitehead's thought occurred in 1925 when, while extending his results as a mathematical physicist and philosopher of science to metaphysical and cosmological issues, he expressed for the first time his «organic theory». He developed this theory by generalizing the undulatory ontology suggested by electromagnetism within evolutionism. Melting the critique of the existence of the materialist's durationless simply located entities (his scheme's *pars destruens*) with his thematization of life as rhythmical (his *part construens*), Whitehead substituted definitively the mechanistic «bit of material» with the notion of «complete organism», the «vibratory primate»:

A proton, and perhaps an electron, would be an association of such primates, superposed on each other, with their frequencies and spatial dimensions so arranged as to promote the stability of the complex organism, when jolted into acceleration of locomotion. The conditions for stability would give the associations of periods possible for protons. The expulsion of a primate would come from a jolt which leads the proton either to settle down into an alternative association, or to generate a new primate by the aid of the energy received. [...] In this particular hypothesis of vibratory primates, the Maxwellian equations are supposed to hold throughout all space, including the interior of a proton. They express the laws governing the vibratory production and absorption of energy. The whole process for each primate issues in a certain average energy characteristic of the primate, and proportional to its mass. In fact the energy is the mass. There are vibratory radial streams of energy, both without and within a primate. Within the primate, there are vibratory distributions of electric density. On the materialistic theory such density marks the presence of material: on the organic theory of vibration, it marks the vibratory production of energy. Such production is restricted to the interior of the primate<sup>52</sup>.

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<sup>50</sup> Ivi, pp. 72-3.

<sup>51</sup> Ivi, p. 73.

<sup>52</sup> Id., *Science and Modern World*, cit., pp. 135 e 136.

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What Whitehead made was a rational generalization of the notion of functionality and periodicity now applied to microscopic quantum entities. In this way he followed the path which was traced by the scientific revolution, a revolution that in his opinion was enabled by the mathematical «background of imaginative thought»:

[...] the idea of functionality in the abstract sphere of mathematics found itself reflected in the order of nature under the guise of mathematically expressed laws of nature. Apart from this progress of mathematics, the seventeenth century developments of science would have been impossible. Mathematics supplied the background of imaginative thought with which the men of science approached the observation of nature. [...] As a particular example of the effect of the abstract development of mathematics upon the science of those times, consider the notion of periodicity. The general recurrences of things are very obvious in our ordinary experience. [...] Apart from recurrence, knowledge would be impossible; for nothing could be referred to our past experience. Also, apart from some regularity of recurrence, measurement would be impossible. In our experience, as we gain the idea of exactness, recurrence is fundamental. [...] The birth of modern physics depended upon the application of the abstract idea of periodicity to a variety of concrete instances. But this would have been impossible unless mathematicians had already worked out in the abstract the various abstract ideas which cluster round the notions of periodicity. [...] It illuminated the underlying analogy between sets of utterly diverse physical phenomena; and at the same time it supplied the weapons by which any one such set could have its various features analysed and related to each other<sup>53</sup>.

Through the introduction of the «hypothesis of vibratory primates», one very important distinction occurred at this stage of Whitehead's work: the differentiation between «vibratory locomotion» and «vibratory deformation», since according to him, «there is vibratory locomotion of a given pattern as one whole, and there is vibratory change of pattern»<sup>54</sup>. The former is associated with the movement through time-space of an electron or of a proton, when considered as «a society of electronic occasions» or of «protonic occasions»<sup>55</sup> with a high degree of internal stability:

Now in discussing the theory of relativity, we saw that the relative motion of two primates means simply that their organic patterns are utilising diverse space-time systems. If two primates do not continue either mutually at rest, or mutually in uniform relative motion, at least one of them is changing its intrinsic space-time system. The laws of motion express the conditions under which these changes of space-

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<sup>53</sup> Ivi, pp. 32-3.

<sup>54</sup> Ivi, p. 133.

<sup>55</sup> Id., *Process and Reality*, cit., p. 91.

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time systems are effected. The conditions for vibratory *locomotion* are founded upon these general laws of motion<sup>56</sup>.

Probably remembering his Concept IV from 1905, whose «interpoints» disintegrated from instant to instant, Whitehead hypothetically imagined that primates, in changing their time-space systems, could lose their organic pattern. To avoid this resting ephemerality, the primates have to create an association which works as a stable environment for their survival:

[certain species of primate] would only experience a long range of endurance, if they had succeeded in forming a favourable association among primates of different species, such that in this association the tendency to collapse is neutralised by the environment of the association. [...] There are certain indications in modern physics that the role of corpuscular organisms at the base of the physical field, we require vibratory entities. Such corpuscles would be the corpuscles detected as expelled from the nuclei of atoms, which then dissolve into waves of light. We may conjecture that such a corpuscular body has no great stability of endurance, when in isolation. Accordingly, an unfavourable environment leading to rapid changes in its proper space-time system, that is to say, an environment jolting it into violent accelerations, causes the corpuscles to go to pieces and dissolve into light-waves of the same period of vibration<sup>57</sup>.

The main difference of his organic theory compared with materialist substantialism concerns the denial of entities' undifferentiated endurance. Indeed, as Whitehead explains:

in the organic theory, a pattern need not endure in undifferentiated sameness through time. The pattern may be essentially one of aesthetic contrasts requiring a lapse of time for its unfolding. A tune is an example of such a pattern. Thus the endurance of the pattern now means the reiteration of its succession of contrasts. [...] But when we translate this notion into the abstractions of physics, it at once becomes the technical notion of 'vibration'. This vibration is not the vibratory locomotion: it is the vibration of organic deformation<sup>58</sup>.

A musical example returns. The ontology of rhythms requires this way to qualify the concept of organic deformation. The ultimate actual entities are constituted of pulsing «phases» and rhythmical «contrasts», which in their integrated unity will constitute the occasion's individuality. But, notice that individuality does not mean simplicity. Indeed, there is both an internal complexity of the periodic entity as well as an external one connected with a second fashion of the organic deformation:

<sup>56</sup> Id., *Science and Modern World*, cit., p. 134.

<sup>57</sup> Ivi, pp. 134-35.

<sup>58</sup> *Ibidem*

It is quite easy (as a particular hypothesis) to imagine stationary vibrations of the electromagnetic field of definite frequency, and directed radially to and from a centre, which, in accordance with the accepted electromagnetic laws, would consist of a vibratory spherical nucleus satisfying one set of conditions and a vibratory external field satisfying another set of conditions. This is an example of vibratory organic deformation [1948:135].

From his studies in mathematical physics Whitehead discovered the notion of a pervading activity: «Mathematical physics presumes in the first place an electromagnetic field of activity pervading space and time»<sup>59</sup>, he said, implicitly referring to Poynting's theorem<sup>60</sup>. This activity is rhythmically, periodically pulsing. Again, notice that Whitehead does not concede too much importance to the cognitive faculties of human observers since «the philosophy of organism is the inversion of Kant's philosophy»<sup>61</sup>. For, from this epistemological position, Whitehead's project was a new ontology rooted in the periodical processes that nature exhibits, while quantum mechanics, in the complementarity principle's rendering, is devoid of existential reference<sup>62</sup>. For Whitehead,

[...] the intrinsic character of the observer is merely relevant in order to fix the self-identical individuality of the physical entities. These entities are only considered as agencies in fixing the routes in space and in time

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<sup>59</sup> Ivi, p. 153.

<sup>60</sup> J. H. Poynting, *On the Transfer of Energy in the the Electromagnetic Field*, «Philosophical Transactions of the Royal Society of London» 175,1884, pp. 343–361. Almost ten years after, when the quantum mechanics was already born, Whitehead kept his own understanding about the foundations of physics: «The science of physics conceives a natural occasion as a locus of energy. Whatever else that occasion may be, it is an individual fact harboring that energy. The words electron, proton, photon, wave-motion, velocity, hard and soft radiation, chemical elements, matter, empty space, temperature, degradation of energy, all point to the fact that physical science recognizes qualitative differences between occasions in respect to the way in which each occasion entertains its energy. These differences are entirely constituted by the flux of energy, that is to say, by the way in which the occasions in question have inherited their energy from the past of nature, and in which they are about to transmit their energy to the future. The discussion of the Poynting Flux of Energy is one of the most fascinating chapters of Electrodynamics. Forty-seven years ago, when a young graduate student, I first heard of it in a lecture delivered by Sir J. J. Thomson. It was then a new discovery recently published by Poynting. But its father was the great Clerk-Maxwell who had expounded all the requisite principles. The sole conclusion with which we are concerned is that energy has recognizable paths through time and space. Energy passes from particular occasion to particular occasion. At each point there is a flux, with a quantitative flow and a definite direction.»; cfr. A. N. Whitehead, *Adventures of Ideas*, The Free Press, New York, 1969, pp. 237-38 (1933).

<sup>61</sup> A. N. Whitehead, *Process and Reality*, cit., p. 88.

<sup>62</sup> J. Faye, *Niels Bohr: His Heritage and Legacy. An Anti-Realist View of Quantum Mechanics*, Kluwer, Dordrecht, 1991; J. Faye, J. H. Folse, (Eds.), *Niels Bohr and contemporary philosophy*, Kluwer Academic Publishers, Dordrecht, 1994; D. Kaiser, *More Roots of Complementarity: Kantian Aspects and Influence*, in «Studies in the History and Philosophy of Science», Vol. 23, n. 2, 1992, pp. 213-239; D. Favrholt, *Niels Bohr Philosophical Background*, Munksagaard, Copenhagen, 1992; Id., *General Introduction: Complementarity Beyond Physics*, in D. Favrholt (Ed.), *Niels Bohr Collected Works, Vol. 10: Complementarity Beyond Physics*, Elsevier, Amsterdam 1999, pp. xiii-xlix; M. E. Cuffaro, *The Kantian Framework of Complementarity*, in «Studies in History and Philosophy of Modern Physics», 41, 2010, pp. 309-317.

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of the life histories of enduring entities. The phraseology of physics is derived from the materialistic ideas of the seventeenth century. But we find that, even in its extreme abstraction, what it is really presupposing is the organic theory of aspects as explained above. First, consider any event in empty space where the word 'empty' means devoid of electrons, or protons, or of any other form of electric charge. Such an event has three roles in physics. In the first place, it is the actual scene of an adventure of energy, either as its habitat or as the locus of a particular stream of energy: anyhow, in this role the energy is there, either as located in space during the time considered, or as streaming through space. In its second role, the event is a necessary link in the pattern of transmission, by which the character of every event receives some modification from the character of every other event. In its third role, the event is the repository of a possibility, as to what would happen to an electric charge, either by way of deformation or of locomotion, if it should have happened to be there<sup>63</sup>.

To state «the fundamental truth that objectification is abstraction»<sup>64</sup> does not mean in Whitehead's philosophy the lack of reference to an external reality, but only the selection of some factors inherent to the actual world. For this reason the electromagnetic field has to be seen as a narrow rendering of a more concrete and complex activity, just as the atomic vibratory periodical character of ultimate entities is a rendering of the abstractions of physics of their living rhythmical nature. The rhythmical life of quantum entities is «directed radially to and from a centre» in a way that enables us to consider them as localized onto a locus of time-space relationships, from one side, but from the other as not *simply* located either in a spatial point or volume, or in a definite duration:

Modern physics has abandoned the doctrine of Simple Location. The physical thing which we term stars, planets, lumps of matter, molecules, electrons, protons, quanta of energy, are each to be conceived as modifications of conditions within spatio-temporal, extending throughout its whole range. There is a focal region, which in common speech is where the thing is. But its influence streams away from it with finite velocity throughout the utmost recesses of space and time [...] For physics, the thing itself is what it does, and what it does is this divergent stream of influence. Again the focal region cannot be separate from the external stream. It obstinately refuses to be conceived as an instantaneous fact. It is a state of agitation, only differing from the so-called external stream by its superior dominance within the focal region<sup>65</sup>.

<sup>63</sup> Id., *Science and Modern World*, cit., pp. 153-4.

<sup>64</sup> Id., *Process and Reality*, cit., p. 101.

<sup>65</sup> Id., *Adventures of Ideas*, The Free Press, New York, 1967 (1933), p. 157.

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## 7. Metaphor and analogy in scientific rationality and comunicability

One thing that needs to be underlined at this point is that while discussing the bewilderment springing from modern scientific achievements, not reduced to sole quantum theory, Whitehead exemplified his philosophical generalization through the usage of macroscopic images. In this sense it seems to me that one of his great merits was to try to overcome the strangeness of quantum phenomenology by showing the quantized aspects of existence at all scales of reality. The quantized character of the world is explained as a consequence of the fact the every «value» is a gift from finitude, the latter being the necessary condition for the «activity». Indeed, according to him philosophy has to lose its «superstitious» apprehension of the «infinite», since it has in itself no «meaning», no «property», and no «value», as he will say in *Mathematics and the Good*<sup>66</sup>. Now, by deriving the spatial notion from the rhythmical duration of events, as well as by visualizing it through macroscopic metaphors, Whitehead lessened the paradoxical feature of quantum mechanics:

There is no difficulty in explaining the paradox, if we consent to apply to the apparently steady undifferentiated endurance of matter the same principles as those now accepted for sound and light. A steadily sounding note is explained as the outcome of vibrations in the air: a steady colour is explained as the outcome of vibrations in ether. If we explain the steady endurance of matter on the same principle, we shall conceive each primordial element as a vibratory ebb and flow of an underlying energy, or activity. Suppose we keep to the physical idea of energy: then each primordial element will be an organised system of vibratory streaming of energy. Accordingly there will be a definite period associated with each element; and within that period the stream-system will sway from one stationary maximum to another stationary maximum - or, taking a metaphor from the ocean tides, the system will sway from one high tide to another high tide. This system, forming the primordial element, is nothing at any instant. It requires its whole period in which it manifest itself. In an analogous way, a note of music is nothing at an instant, but it also requires its whole period in which to manifest itself. Accordingly, in asking where the primordial element is, we must settle on its average position at the centre of each period. If we divide time into smaller elements, the vibratory system as one electronic entity has no existence. The path in space of such a vibratory entity - where the entity is constituted by the vibrations must be represented by a series of detached positions in space, analogously to the automobile which is found at successive milestones and at nowhere between<sup>67</sup>.

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<sup>66</sup> Id., *Mathematics and the Good*, in Id., *Essays in Science and Philosophy*, Philosophical Library, New York, 1947.

<sup>67</sup> Id., *Science and Modern World*, cit., pp. 37-8. The metaphor of the ocean tide used by Whitehead is to my understanding clearly inspired by Faraday: «the manner in which two or many centres of force may in this way combine, and afterwards, under the dominion of stronger forces, separate again, may in some degree be illustrated by the beautiful case of the conjunction of two sea waves of different velocities into one, their perfect union for a time, and final separation into the constituent waves», cfr. M. Faraday, “A speculation touching

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A primate, or an «actual occasion», as «a limiting type of event»<sup>68</sup>, is a periodical process that cannot be divided without destroying it. There is no way, during its internal process of emergence, to divide a pulsing rhythms of nature. Only *a posteriori*, by means of the abstract objective elements that relate it to the systematic field of connections, are some of its factors analysable:

The organic starting point is from the analysis of process as the realisation of events disposed in an interlocked community. The event is the unit of things real. The emergent enduring pattern is the stabilisation of the emergent achievement so as to become a fact which retains its identity throughout the process. It will be noted that endurance is not primarily the property of enduring beyond itself, but of enduring within itself. I mean that endurance is the property of finding its pattern reproduced in the temporal parts of the total event. It is in this sense that a total event carries an enduring pattern. There is an intrinsic value identical for the whole and for its succession of parts<sup>69</sup>.

If you try to study either a musical note or an ocean tide or a quantum entity at the microscopic level without tuning your observation on the internal rhythmical pattern of the phenomena under consideration, you get nothing at all – the entity does not exist for you. Technically, translated into the language of physics, the rhythmical pulsations are «vibration», while, according to Whitehead's view, in a deeper and more concrete meaning these are «emotional feelings»:

In the phraseology of physics, this primitive experience is 'vector feeling', that is to say, feeling from a beyond which is determinate and pointing to a beyond which is to be determined. But the feeling is subjectively rooted in the immediacy of the present occasion: it is what the occasion feels for itself, as derived from the past and as merging into the future. In this vector transmission of primitive feeling the primitive provision of width for contrast is secured by pulses of emotion, which in the coordinate division of occasions (d. Part IV) appear as wave-lengths and vibrations. In any particular cosmic epoch, the order of nature has secured the necessary differentiation of function, so as to avoid incompatibilities, by shepherding the sensa characteristic of that epoch each into association with a definite pulse. Thus the transmission of each sensum is associated with its own wave-length<sup>70</sup>.

Even if we cannot conduct a detailed analysis of *PR* in the present work, what is interesting for us is that the distinction between first and second

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Electric Conduction and the Nature of Matter”, em *Philosophical Magazine*, Vol. 24, No. 157, 1844, p. 142.

<sup>68</sup> Id., *Process and reality*, cit., p. 80.

<sup>69</sup> Id., *Science and Modern World*, cit., pp. 152-53.

<sup>70</sup> Id., *Process and Reality*, cit., p. 164.

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qualities, typical of modern philosophy, is overcome by asserting the equivalence (in Whitehead's sense of the word) between different languages, such as that of science and that of common experience. So, what the symbols of mathematical physics express as the vibrational properties of a wavelike entity should be interpreted as being an abstract narrow account of the «pulses of emotion» by which the universe is created. The «systematic mutual relatedness which is inherent in the character of possibility»<sup>71</sup> does not exclude but on the contrary enables the diversification of modes of ingression in a concrete situation. For, even if «each object stands internally in all its possible relationships»<sup>72</sup>, «an indeterminateness stands in the essence of any eternal object»<sup>73</sup>. Each «occasion of experience», as an «aesthetics synthesis» conditioned by the actual world's history, «selects» and realizes only some of the relationships that qualify the status of object in the realm of possibility. In any actual occasion there is a multiplicity of objects that ingress in a new and unique way due to the locus from which the occasion springs. The modes of synthesis, termed «contrasts» by Whitehead, are the eighth «category of existence»<sup>74</sup>:

That whatever is a datum for a feeling has a unity *as felt*. Thus the many components of a complex datum have a unity: this unity is a 'contrast' of entities. In a sense this means that there are an endless number of categories of existence, since the synthesis of entities into a contrast in general produces a new existential type. For example, a proposition is, in a sense, a 'contrast'<sup>75</sup>.

In a sense we can see in the distinction between the «analytical character» of the ubiquitous object's realm and of the potentiality ascribed to the extensive continuum, on the one hand, and the synthetic character of the actual occasion, on the other<sup>76</sup>, an application to cosmology made by the *Universal Algebra's* notion of «positional manifold» as a relational scheme that is continuous in its extensive nature, while its loci and their intensities are discrete. Both features of mathematics, its «truism» and its «paradox», are reproduced by Whitehead in his cosmology, where the opposition between continuity and atomicity is resolved as a dialectic between potentiality and actuality:

It will be remembered that the continuity of the complex of events arises from the relationships of extensiveness; whereas the temporality arises from the realisation in a subject-event of a pattern which requires for its display that the whole of a duration be spatialised (i.e., arrested), as given by its aspects in the event. Thus realisation proceeds via a succession of epochal durations; and the continuous transition, i.e., the organic deformation, is within the duration which is already given. The

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<sup>71</sup> Id., *Science and Modern World*, cit., p. 161.

<sup>72</sup> Ivi, p. 165.

<sup>73</sup> Ivi, p. 162.

<sup>74</sup> Id., *Process and Reality*, cit., p. 22.

<sup>75</sup> Ivi, p. 24.

<sup>76</sup> Id., *Science and Modern World*, cit., pp. 164 e sgg.

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vibratory organic deformation is in fact the reiteration of the pattern. One complete period defines the duration required for the complete pattern. Thus the primate is realised atomically in a succession of durations, each duration to be measured from one maximum to another. Accordingly, so far as the primate as one enduring whole entity is to be taken account of, it is to be assigned to these durations successively. If it is considered as one thing, its orbit is to be diagrammatically exhibited by a series of detached dots. Thus the locomotion of the primate is discontinuous in space and time. If we go below the quanta of time which are the successive vibratory periods of the primate, we find a succession of vibratory electromagnetic fields, each stationary in the space-time of its own duration. Each of these fields exhibits a single complete period of the electromagnetic vibration which constitutes the primate. This vibration is not to be thought of as the becoming of reality; it is what the primate is in one of its discontinuous realisations. Also the successive durations in which the primate is realised are contiguous; it follows that the life history of the primate can be exhibited as being the continuous development of occurrences in the electromagnetic field. But these occurrences enter into realisation as whole atomic blocks, occupying definite periods of time<sup>77</sup> [1948:137].

The «epocal theory of time», according to which Zeno's paradox can be solved by distinguishing between continuity as potential and discreteness as actual, leads Whitehead to radically modify what the word «atomic» means:

[...] there is a becoming of continuity, but no continuity of becoming. The actual occasions are the creatures which become, and they constitute a continuously extensive world. In other words, extensiveness becomes, but 'becoming' is not itself extensive. Thus the ultimate metaphysical truth is atomism. The creatures are atomic. [...] But atomism does not exclude complexity and universal relativity. Each atom is a system of all things [1978:35-36].

On the one hand, in *Process and Reality*, atomism is referred to as «the modern quantum theory»<sup>78</sup>, where

the atomization of the extensive continuum is also its temporalization; that is to say, it is the process of the becoming of actuality into what in itself is merely potential. The systematic scheme, in its completeness embracing the actual past and the potential future, is prehended in the positive experience of each actual entity<sup>79</sup>.

On the other hand, in *SMW*, the theory of an atomic, epocal temporality is deemed by Whitehead as a corollary of his «doctrine of events,

<sup>77</sup> Ivi, p. 137.

<sup>78</sup> Id., *Process and Reality*, cit., p. 238.

<sup>79</sup> Ivi, p. 72.

and of the nature of enduring objects» and it is only subsidiarily applied to «the quantum theory of modern science», from which it has to be considered at least partially independent:

Temporalisation is not another continuous process. It is an atomic succession. Thus time is atomic (i.e., epochal), though what is temporalised is divisible. This doctrine follows from the doctrine of events, and of the nature of enduring objects. In the next chapter we must consider its relevance to the quantum theory of recent science<sup>80</sup>.

Thus, in contrast to claims made by Tanaka<sup>81</sup>, what Whitehead did was precisely to originally elaborate a «temporal atomism» where the 'atoms' are rhythmical organisms with complex «ultimate vibratory characters»<sup>82</sup>. Only by identifying the concept of rhythm, with its internal duration and patterned complexity, as the basis for the theory of prehension and that of epochal becoming, can his philosophy be duly appreciated with regard to the issues springing from twentieth century physics. For him, the process of realization implies the synthetic limitation of the analytic realm of potentiality. The potentiality of the extensive continuity becomes an extended and complex, albeit atomic, pulsing mode of the general activity of the universe. Notice that this process of the actualization of potentiality has nothing to do with the presence of a human observer or of an instrumental context. Indeed, our thesis is that something completely absent in quantum mechanics is the true cornerstone of Whitehead's thought: an ontology<sup>83</sup>. This ontology melts together the concept of rhythmical duration with that of living organism:

[The] materialistic concept has proved to be as mistaken for the atom as it was for the stone. The atom is only explicable as a society with activities involving rhythms with their definite periods. Again the concept shifted its application: protons and electrons were conceived

<sup>80</sup> Id., *Science and Modern World*, cit., p. 129.

<sup>81</sup> Y. Tanaka, *The Problem of the Indeterminate Past in Quantum Physics and Whitehead's Epochal Theory of Time*, Lecture delivered at the 9th International Whitehead Conference 2013/9/9.

<sup>82</sup> A.N. Whitehead, *Process and Reality*, cit., p. 239.

<sup>83</sup> The French philosopher Gaston Bachelard, plausibly due to the relevance of the French physicist Louise de Broglie, acknowledge the new scientific ontology of rhythms: «Le panpsychisme n'est plus qu'un panchronisme. [...] Le temps est vivant et la vie est temporelle. [...] la matière doit avoir, comme les radiations, des caractères ondulatoires et rythmique. La matière n'est pas étalée dans l'espace, indifférente au temps; elle ne subsiste pas toute constante, tout inerte, dans une durée uniforme. [...] elle *existe*, dans toute la force du terme, sur le plan du rythme, et le temps où elle développe certaines manifestations délicates est un temps ondulant, temps qui n'a qu'une manière d'être uniforme: la régularité de sa fréquence. Les diverses puissances substantielles de la matière, dès qu'on les étudie dans leur détail, se présentent comme des fréquences. [Les solides] sont les figures statistique d'un désordre temporel; rien de plus. Nos maisons sont construites avec une anarchie de vibrations. Nous marchons sur une anarchie de vibrations. Nous nous asseyons sur une anarchie de vibrations. [...] On peut donc dire que l'énergie vibratoire est l'*énergie d'existence*. [...] Pour nous, le temps primitif est le temps vibré. [...] La doctrine des rapports de la substance et du temps se présente donc sous un jour métaphysique nouveau: on ne doit pas dire que la substance se développe et se manifeste sous la forme du rythme; on doit dire que c'est le rythme *régulier* qui apparaît sous forme d'attribut matériel *déterminé*.» Bachelard G., *La dialectique de la durée*, Presses Universitaires de France, Paris, (1950) 1972, pp. 2 and 130-2.

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as materialistic electric charges whose activities could be construed as locomotive adventures. We are now approaching the limits of any reasonable certainty in our scientific knowledge; but again there is evidence that the concept may be mistaken. The mysterious quanta of energy have made their appearance, derived, as it would seem, from the recesses of protons, or of electrons. Still worse for the concept, these quanta seem to dissolve into the vibrations of light. Also the material of the stars seems to be wasting itself in the production of the vibrations. Further, the quanta of energy are associated by a simple law with the periodic rhythms which we detect in the molecules. Thus the quanta are, themselves, in their own nature, somehow vibratory; but they emanate from the protons and electrons. Thus there is every reason to believe that rhythmic periods cannot be dissociated from the protonic and electronic entities. The same concept has been applied in other connections where it even more obviously fails. It is said that 'men are rational'. This is palpably false: they are only intermittently rational - merely liable to rationality<sup>84</sup>.

In the «real internal constitution» of an actual entity the «evaporation» of the indeterminateness of ubiquitous objects transmitted to them by the past occurs, and I quote:

so that there is a complete determination of 'feeling', or of 'negation of feeling', respecting the universe. This evaporation of indeterminateness is merely another way of considering the process whereby the actual entity arises from its data<sup>85</sup>.

This evaporation has nothing to do with the «wave-function collapse», since it is completely observer-independent. Still, it is important to stress that organic theory provided an ontological basis for causal connection and that this was founded on the immanence of the past in the time-space regional locus where the present actual occasions emerge from. For that reason, locality and causation are interwoven concepts in the cosmological scheme, an aspect quite opposite to the quantum mechanics interpretation of quantum phenomena. Generalizing the *UA*'s calculus of extension to a cosmological extent, Whitehead claimed that the achievement of value and of intensity of experience requires the general ubiquitous objects' potentiality to be limited. This limitation, which guarantees the function of the extensive continuum as a medium for the transmission of the reality's objective factors, merges causation and locality:

[...] the extensive space-time continuum is the fundamental aspect of the limitation laid upon abstract potentiality by the actual world. A more complete rendering of this limited, 'real' potentiality is the 'physical field'. A new creation has to arise from the actual world as much as from pure potentiality: it arises from the total universe and not

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<sup>84</sup> Ivi, p. 78.

<sup>85</sup> Ivi, p. 45.

solely from its mere abstract elements. It also adds to that universe. Thus every actual entity springs from *that* universe which there *is for it*. Causation is nothing else than one outcome of the principle that every actual entity has to house *its* actual world<sup>86</sup>.

It follows that a philosophical frame capable of facing scientific knowledge must give an account of the existence of structural factors independent from the human knowing subjects. Indeed, according to Whitehead, reality is an impartial world within which human subjectivity is nothing but an «ego-object amid objects»

The primary situation disclosed in cognitive experience is 'ego-object amid objects'. By this I mean that the primary fact is an impartial world transcending the 'here-now' which marks the ego-object, and transcending the 'now' which is the spatial world of simultaneous realisation<sup>87</sup>.

They were and are just the rhythmical occasions, according to Whitehead, not the alleged transcendental human subject, that create the dynamic order of nature:

Thus the physical relations, the geometrical relations of measurement, the dimensional relations, and the various grades of extensive relations, involved in the physical and geometrical theory of nature, are derivative from a series of societies of increasing width of prevalence, the more special societies being included in the wider societies. This situation constitutes the physical and geometrical order of nature<sup>88</sup>.

They were the occasions that created and maintain «the society of pure extension», the «'geometrical' society», the «'electromagnetic' society»<sup>89</sup>, and so on,

[...] thus ultimately all science depends upon direct observation of homology of status within a system. Also the observed system is the complex of geometrical relations within some presented locus<sup>90</sup>.

## 8. A living, ecstatic universe

If on one side Heisenberg's principle of uncertainty, Bohr's principle of complementarity, and the von Neumann orthodox interpretation of quantum mechanics have transformed the ontological question about the quantum

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<sup>86</sup> Ivi, pp. 79-80.

<sup>87</sup> Id., *Science and Modern World*, cit., p. 152.

<sup>88</sup> Id., *Process and Reality*, cit., p. 92.

<sup>89</sup> Ivi, pp. 97-8.

<sup>90</sup> Ivi, p. 128.

domain into an epistemological one<sup>91</sup>, Whitehead continued on an opposing path:

All metaphysical theories which admit a disjunction between the component elements of individual experience on the one hand, and on the other hand the component elements of the external world, must inevitably run into difficulties over the truth and falsehood of propositions, and over the grounds for judgment. The former difficulty is metaphysical, the latter epistemological. But all difficulties as to first principles are only camouflaged metaphysical difficulties. Thus also the epistemological difficulty is only solvable by an appeal to ontology. [...] For the purpose of this discussion it is indifferent whether we speak of a 'stream' of experience, or of an 'occasion' of experience. With the former alternative there is togetherness in the stream, and with the latter alternative there is togetherness in the occasion. In either case, there is the unique 'experiential togetherness'. [...] This reformed version of the subjectivist doctrine is the doctrine of the philosophy of organism<sup>92</sup>.

Now, to avoid misunderstanding, it is urgent to state that Whitehead's «reform» went in the opposite direction of that followed by all modern traditional doctrines, namely Descartes' rationalism, Hume's empiricism and Kant's transcendental idealism. In fact, Whitehead ascribes to ultimate entities not only the «internal relation» that structures the order of nature, but also the internal appetition and the teleological subjectivity that drives the solidarity of universe toward a higher emergent complexity. The «substance» by and within which we live is nature's pulsing emotions (*ex + movere*). Natural becoming is an ordered multiple stream of rhythmical ecstasy. It is its ecstatic autopoietic life. Indeed, to remedy «the failure of science to endow its formulae for activity with any meaning»<sup>93</sup> the organicist philosophy established equivalence between actuality and living subjectivity: «The key notion from which the construction should start is that energetic activity considered in physics is the emotional intensity entertained in life»<sup>94</sup>:

The emotion transcends the present in two ways. It issues from, and it issues towards. It is received, it is enjoyed, and it is passed along, from moment to moment. Each occasion is an activity of concern, in the Quaker sense of that term. It is the conjunction of transcendence and immanence. The occasion is concerned, in the way of feeling and aim, with things that in their own essence lie beyond it; although these things in their present functions are factors in the concern of that occasion. Thus each occasion, although engaged in its own immediate self-realization, is concerned with the universe.

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<sup>91</sup> Selleri F., *Quantum Paradoxes and Physical Reality*, Kluwer, Dordrecht, 1990; Id., *La fisica del Novecento. Per un bilancio critico*, Progedit, Bari, 1999; Id., *La fisica tra paradossi e realtà, Le critiche dei fisici realisti alla teoria dei quanti*, Progedit, Bari, (2001) 2005.

<sup>92</sup> Ivi, p. 189.

<sup>93</sup> Id., *Modes of Thought*, Capricorn Books, New York, 1938, p. 210.

<sup>94</sup> Ivi, pp. 231-32.

The process is always a process of modification by reason of the numberless avenues of sup-ply, and by reason of the numberless modes of qualitative texture. The unity of emotion, which is the unity of the present occasion, is a patterned texture of qualities, always shifting as it is passed into the future. The creative activity aims at preservation of the components and at preservation of intensity. The modifications of pattern, the dismissal into elimination, are in obedience to this aim<sup>95</sup>.

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<sup>95</sup> *Ivi*, pp. 230-31.

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