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Whitehead and the Lisbon School of Quantum Physics

Whitehead e a Escola de Lisboa de Física Quântica

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Abstract
In the controversy on the philosophical foundations of quantum mechanics, Whitehead's philosophy of organism has an essential place. But its realistic position invalidates any attempt to relate it to the School of Copenhagen's “orthodox interpretation”. Unlike, the Eurhythmic Physics developed by the Lisbon School has notable theoretical tunings with Whitehead's philosophy. In both, the notion of passive matter disappears; entities are understood as ecstatic process of becoming arising from a continuum of potentialities; and they achieve physical persistence grace to a set of synergistic interactions among their own regimes of rhythmical activity. The principle of Eurhythmy proposed by Prof. Croca then appears as the hypothesis, in contemporary theoretical physics, corresponding to the organicist vision of a universe in a developmental process of realization of the abstract potentiality of all possible worlds: a universe that, as a living organism, should be described as guided by an immanent teleological principle.

Keywords
Whitehead. Principle of Eurhythmy. Organic Universe. Immanent Teleology. Intensity of Experience.

Resumo
Na controvérsia sobre os fundamentos filosóficos da mecânica quântica, a filosofia do organismo do Whitehead tem um lugar incontornável. Contudo a sua posição realista invalida qualquer tentativa de o relacionar com a "interpretação ortodoxa" da Escola de Copenhaga. Ao passo contrario a Física Eurítmica elaborada pela Escola de Lisboa apresenta notáveis sintonias teóricas com a filosofia do Whitehead. Em ambas a noção de matéria passiva desaparece; as entidades são entendidas como emergentes de um continuum de potencialidades; e alcançam persistência física graça à um conjunto de interações sinérgicas entre os seus regimes de actividade rítmica. O principio de euritmia proposto pelo Prof. Croca afigura-se então como a hipótese, na física teórica contemporânea, correspondente a visão organicista de um universo em processo de desenvolvimento através da realização das potencialidades abstractas de todos os mundos possíveis: um universo que, enquanto organismo vivo, deve ser descrito como guiado por um principio teleológico imanente.

Palavras-chave
Whitehead. Principio de Euritmia. Universo Orgânico. Teleologia Imanente. Intensidade de Experiência.

1. Premise

My aim in this paper is to point out some resonances between Whitehead's organicist cosmology and the new vision of *physis* grounded in Croca's Hyperphysics, also called Eurhythmic Physics. This vision is a work in process in what I've called in preceding works, the Lisbon School (MAZZOLA, 2015, 2016, 2017, 2020ab, 2022). It is important to stress that I speak of resonances and not of heritage because Lisbon's scholars have undertaken their theoretical journeys without inspiring themselves with Whitehead's philosophy. These two moments in the adventures of scientific and philosophical ideas are then quite independent from each other, in spite of the fact that they are both rooted in the common claim for rendering intelligible the rhythmical temporality of becoming. On the one side, Lisbon School scholars are developing de Broglie's quantum physical proposals and then rejecting the quantum mechanics' orthodox interpretation, while, on the other hand, Whitehead's thought was formulated before of the advent of the latter, having between them several incompatible features. For these historical features, the tunings we are going to show are a reason for plenty interest.

2. Processual relational realism

Let's begin by reviewing the five basic assumption upon which the Lisbon School approach is built:

> 1. There is an objective Reality. This reality is observer-independent, yet, it is understood that the observer interacts with the very same reality, being able to change it, and of course being changed by it to a greater or lesser degree.
>
> 2. There is a basic physical natural chaotic medium named the subquantum medium. All physical processes occur in this natural chaotic medium.

> 3. What are called physical entities, that is, the particles, fields and so on, are more or less stable local organizations of the basic chaotic subquantum medium.
>
> 4. In general, the complex particles – stable organizations of the subquantum medium – are composed of an extended region, the so-called theta wave, and inside it there is a kind of very small localized structure, the acron.
>
> 5. The principle of eurhythmy. This organizing principle states that the acron inside the theta wave field follows a stochastic path that in average leads it to regions where the intensity of the theta wave field is greater. (CROCA, 2020, p. 9)

The general philosophical position expressed by the first assumption resonates with what we can call the *processual relational realism* of Whitehead's philosophy: natural entities are interrelated processes. Whitehead's processual relational realism can be summarized through the conjunction of his «principle of process» and «principle of relativity»:

> […] *how* an actual entity becomes constitutes *what* that actual entity *is*; so that the two descriptions of an actual entity are not independent. Its "being" is constituted by its "becoming"» (WHITEHEAD, 1978, p. 23);
>
> […] it belongs to the nature of a "being" that it is a potential for every "becoming". (WHITEHEAD, 1978, p. 29)

From the scientific achievements of modern physics, namely electromagnetism, relativity theory and nascent quantum theory, Whitehead saw the urgent need for denouncing the abusive survival of the classical concepts arising from mechanistic Newtonian physics. In truth, his entire philosophical effort has been a search to overcome those concepts. Yet, it is completely useless to try to render his thought as an anticipation of quantum mechanics, since the latter was established by Niels Bohr, via his principle of complementarity, on the ground of his doctrine of the indispensability of classical concepts. Bohr thought that we cannot understand our world of experience without the use of classical concepts, namely the classical concepts of corpuscle and wave, claiming that the use of those concepts is indispensable for describing quantum phenomena or, better said, for giving a meaning to both quantum mechanics' symbolic formalism and experimental output. The same insourmountability is stated by Heisenberg. (HEISENBERG, 1971, pp. 55-56) Nothing could be farther from Whitehead's spirit that any kind of dogmatically alleged finish line for human adventures of ideas. But for the scope of the

present essay I cannot enter into a detailed comparative analysis of similarities and dissimilarities between Whitehead and the so-called Copenhagen interpretation of quantum mechanics (see MAZZOLA 2022). Suffice to say that the latter represents a renunciation of the possibility of describing the quantum domain, while Whitehead's works were going exactly in this ontological forbidden direction:

> But the metaphysical concepts [of matter], which had their origin in a mistake about the stone, were now applied to the individual molecules. Each atom was still a stuff which retained its self-identity and its essential attributes in any portion of time – however short, and however long [...] But this 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. [...] 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. (WHITEHEAD, 1978, pp. 78-79)

Still, let us make clear other two critical points: 1. Whitehead's denial of "simple location" has to do with his realistic attitude facing the notion of "field" as an undulatory component associated with every quantum entity, *both* micro- and macroscopic, while both Bohr's principle of complementarity and his principle of the indispensability of classical concepts are just epistemological (either instrumental or trascendental) escapes from the challenges springing from quantum phenomenology; 2. contrary to what was affirmed by Northrop (HEISENBERG, 1971, Introduction), the concept of potentiality expressed by Heisenberg and that expressed by Whitehead are only superficially similar, since the former has mainly to do with mathematical probability functions while the latter has to do with the structural perdurable factors of natural becoming. Heisenberg followed Bohr's complementarity, accepting the mutual exclusivity of the undulatory and corpuscular entities' features (HEISENBERG, 1971, p. 50), while Whitehead believed in the intrinsic periodical and rhythmical nature of quantum events. Heisenberg's usage of the concept of potentiality had mainly to do with the interpretation of quantum mechanics' formalism as a mere provisional tool where the passage from the «possible» to the «actual» takes place with the act of measurement. According to him «the term "happen" is restricted to the observation» (HEISENBERG, 1971, p. 52): «we have to realize that the word "happen" can apply only to the observation, not to the state of affairs between two observations»

(HEISENBERG, 1971, p. 54). In contrast, for Whitehead, even the so-called "empty space" is fulfilled by an «ether of events», a physical field composed of pulsing happenings that are «occasions of experience» made by «feelings of strains» (WHITEHEAD, 1978, pp. 18, 56, 72, 92, 99, 105-106, 177, 311, 314, 319, 321, 327). As stated by him in 1919:

> Nature is that which we observe in perception through the senses. In this sense-perception we are aware of something which is not thought and which is self-contained for thought. This property of being self-contained for thought lies at the base of natural science. Nature can be thought of as a closed system whose mutual relations do not require the expression of the fact that they are thought about. Thus in a sense nature is independent of thought. [...] the problem of natural philosophy [...] is to discuss the relations *inter se* of things known, abstracted from the bare fact that they are known. (WHITEHEAD, 1920, pp. 3 and 30)

The «concept of nature» that natural science is searching for has to be a rational generalization which originates from the «mutual relations» that we apprehend in perceptive experience. The externality, for thought, of that relationship means that nature is an ordered system in itself, before and beyond the intervention of either the subjective experience or cognitive process. At the same time, Whitehead recognizes that any experience is a limited perspective on the relational system that nature is. The «percipient event» is just one among the unbounded multiplicity of natural events. It pertains to the «ether of events» and then it is constrained by its structural proprieties. Thus, the independence of nature from thought doesn't mean the independence of our experience and thought from nature. The critical turn of Kant's transcendental idealism is explicitly rejected by Whitehead if it means the «doctrine of the objective world as a theoretical construct from purely subjective experience» (WHITEHEAD, 1978, p. XIII); however the importance of Kant's thought resides in the fact that he was «the great philosopher who first, fully and explicitly introduced into philosophy the conception of an act of experience as a constructive functioning, transforming subjectivity into objectivity, or objectivity into subjectivity» (WHITEHEAD, 1978, p. 156). The realistic stance that both Whitehead and Lisbon Scholars assume isn't a naïve realism grounded on some kind of representational epistemology, but on the contrary a "provisional realism" (WHITEHEAD, 1948, pp. 65, 70, 73, 92) that keeps the evolutionary interactive feature of human understanding of natural phenomena:

> It is the basis of any realistic philosophy, that in perception there is a disclosure of objectified data, which are known as having a community with the immediate experience for which they are data. This "community" is a community of common activity involving mutual implication. This premise is asserted as a primary fact, implicitly assumed in every detail of our organization of life. It is implicitly asserted by Locke in his statement (II, XXIII, 7, heading), "Power, a great part of our complex ideas of substances". (WHITEHEAD, 1978, p. 80)

The communality of nature and human cognition is just one particular instance of the ecological nature of reality. In our perceptive experience we are aware that «something is going on» (WHITEHEAD, 1920, p. 49). Then, the fact that nature manifests itself as always «moving on» is the starting point for natural philosophy. This acknowledgment leads Whitehead to the denial of the «absolute theory of time», since time, in its mathematical physics meaning, i.e. as an ordered succession of durationless instants is «an abstraction from the passage of events» (WHITEHEAD, 1920, p. 34). We will return later to Whitehead's understanding of temporality, to his distinction between «physical time», the time understood as «sheer succession», that is the «macroscopic process» of «transition from particular existent to particular existent» (WHITEHEAD, 1978, pp. 210-215), and the «microscopic process», «the genetic process [that] is not the temporal succession» (WHITEHEAD, 1978, pp. 283), and to the similar conceptualization that arises from the Lisbon School's work (CROCA 2021). What is important to underline at this moment it is the world's systematic character, which Whitehead refers to as the «solidarity of the universe», a universe structured by entities' mutual relations and mutual implications at different levels of analysis. Indeed, one of Whitehead's main points against the traditional philosophical systems of thought is that those were falling into incoherence by postulating independent substances, then splitting nature into bifurcated worlds, among which articulation is almost impossible. The influence of Aristotle's metaphysics of substance and qualities, and his logic of subject and predicate are two of the main targets of Whitehead's criticism. On the other hand, the classical atomism at the base of materialistic mechanicism, with its substantialist description of entities is another exemplification of this independence ontology which is attacked by Whitehead:

> The positive doctrine of these lectures is concerned with the becoming, the being, and the relatedness of "actual entities". An "actual entity" is a *res vera* in the Cartesian sense of that term; [...] But

> Descartes retained in his metaphysical doctrine the Aristotelian dominance of the category of "quality" over that of "relatedness". In these lectures "relatedness" is dominant over "quality". (WHITEHEAD, 1978, pp. Xiii-xiv)

3. Eidetic constructivist realism

Whitehead goes even deeper, also denouncing as illegitimate the dualism between the abstractness of *eidos* and the concreteness of phenomenal events. Ultimately, Whitehead sustains explicitly (at least in his later works) a metaphysical doctrine on the reciprocal immanence among the permanent potentiality of ideals – the *eidos* – and the volatile actuality of facts in natural becoming. His constructive and relational epistemology is a reaction against the positivist and instrumentalist nominalism and can be seen as echoing the medieval realism of the philosopher Duns Scotus, or that of C. S. Peirce. For them, it is in the world flux of phenomena that we recognize the existence of permanent elements, and it is by a constructive abstraction process rooted in experience that we get our grasp of those elements. According to Whitehead, 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» (WHITEHEAD, 1920, p. 143). Since recognition is awareness of sameness, and since the streaming events differ from each other, the objects are the factors, the «ingredient» within the events which characterize them as distinct:

> 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". (WHITEHEAD, 1920, p. 144)

Now, remembering from *The Principle of Natural Knowledge* (*PNK*) that the «fundamental relation of extension» is the one that states that an event «extend over» another event (WHITEHEAD, 1919, p. 101), we can also see that objects extend over each other:

> An object is ingredient throughout its neighborhood, and its neighborhood 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. (WHITEHEAD, 1920, p. 145)

The theories of the «eternal objects' realm» and of «prehension» are near. The «constructive task» begun in 1905, and further developed in 1919, while claiming that «investigation into the foundations of geometry has to explain space as a complex of relations between things» (WHITEHEAD, 1919, p. 5), led 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» (WHITEHEAD, 1920, p. 146) means that «nature is such that there can be no events and no objects without the ingression of objects into events» (WHITEHEAD, 1920, p. 144). If «an object is in a sense out of time», being «derivatively in time by reason of its having the relation to events which [Whitehead terms] "situation" » (WHITEHEAD, 1920, p. 78), their existence begins to by understood by Whitehead as ubiquitous potentiality, a kind of existence different from that of the time-space series of events. One more time, it is important to notice 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 frequently seems to suggest this reduction. Indeed, Whitehead arrived at his conclusions before quantum mechanics, and by a thought process independent even from quantum theory. Eventually, as the following text seems to indicate, the physics theory that inspired his philosophical path toward the repudiation of material entities' «simple location» was electromagnetism:

> 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. (WHITEHEAD, 1920, p. 146)

Whitehead distinguished, for the sake of simplicity, different kind of "objects": sensory objects, like color, sound, etc., physical objects, like a stone, a chair, etc., scientific objects, like electrons, protons, etc., and eternal objects, which he describes as «pure potentialities for the definiteness of facts». I think that the adjective "eternal" is a bit overweight since what

characterizes the patterns' abstractness is their reiterative capability,[1] and since the concept of eternality is just an abstraction constructed in opposition to the finitude of existence, and has no experiential correlate. For these reasons I prefer to qualify these objects as "ubiquitous potentiality" since their occurrence can be everywhere. We have no room in the present paper to develop a detailed criticism of this point, which would need to analyze the function of God in Whitehead cosmology and to discuss the sort of dualism he was suggesting as well as rejecting in different phases of his thought. In any case, following Whitehead, all these kinds of objects are factors of events, therefore abstractions from them. The "objects" are ubiquitous potentiality interconnected among each other by 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. (Whitehead, 1948, p. 160)

Our experience's data are complex, and when analyzed, they still exhibit complex components: «Exactness is an ideal of thought, and is only realized in experience by the selection of a route of approximation» (WHITEHEAD, 1920, p. 59). Any event is related with every object by either accepting or rejecting its contribution to itself. For, from the limited specific characteristic of a particular perceived event, it is possible to glimpse also structural systematic aspects not directly perceived:

> There is a structure of events and this structure provides the framework of the externality of nature within which the objects are located. Any percepts which does not find its position within this structure is not for us a percepts of external nature, though it can find its explanation from external events as being derived from them. (WHITHEAD, 1919, p. 80)

Inverting and rejecting the "critical turn" of Kant's transcendental idealism, Whitehead sustained the primacy of the "what" on the "how" of knowledge:

[1] Indeed, as Whitehead explained, «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» (WHITEHEAD, 1948, p. 134).

> An account of the general character of what we know must enable us to frame an account of how knowledge is possible as an adjunct within things known. In any occasion of cognition, that which is known is an actual occasion of experience, as diversified by reference to a realm of entities which transcend that immediate occasion in that they have analogous or different connections with other occasions of experience. (WHITEHEAD, 1948, p. 158)

Knowledge, according to Whitehead, is a constructive task rooted in experience. What rational thought does is to feel the abstract objective factors which are presented to us by sense-recognition. Moreover, through rational generalization, also the elements not directly afforded by experienced events are grasped thanks to their relational connectedness. The systematic solidarity of the world is such that the actual experience is able to show even alternative possibilities still unrealized.

4. A new science and philosophy of rhythms as the basis of complexity, organization and evolution

One of the concerns of rational thought and for instance one of the main «contributions of mathematics to natural science» consists of the elaboration of the theory of «rates of change» (WHITEHEAD, 1919, p. v). Indeed, Whitehead, since his *Treatise of Universal Algebra, with Applications* (1898) and his *On Mathematical Concepts of Material World* (1905, published in 1906) aimed to elaborate, «in its abstract form, the idea of time» and «the existence of change» (WHITEHEAD, 1953, p. 13). For him the materialist and mechanist frame are completely inadequate for giving an account of the basic feature of experience, «the creative advance of nature», and yet some of the fundamental physical quantities, such as «velocity, acceleration, momentum, and kinetic energy» (WHITEHEAD, 1919, p. 2) have no meaning in this frame since these concepts are not understandable assuming a durationless instant of time. It is important to stress that according to Whitehead not only the quantum microscopic phenomenology does not match within the classical conceptual framework, but also phenomenal entities of middle and macroscopic scale: musical notes, ocean tide, pulsing stars, the functioning of an organism or even of an iron. All these cases request a period of time, a duration, a rhythmical interval for existing as such and for being observed and described. From this acknowledgment results

Whitehead's need to distinguish the endless divisibility of mathematical continuity from the actual realization of events.

Keeping these considerations in mind, the tuning with Croca's «physics of becoming» seems plenty sustainable. Croca distinguished «time in the sense of becoming, that is the True Time», from the «chronological time that is […] a measurement that we make with the help of space». The former is deemed as the more basic feature of nature «since the very definition of state implies this ever changing», while the latter, jointly with space, is just a helpful secondary concept (CROCA, 2013, p. 30):

> Chronological time is nothing more than a link between space and the primordial concept of Becoming of Changing. […] Chronological time, the time of the clock, is polluted by the concept of space therefore cannot have the same basic ontological status of the Becoming, of the true Time. (CROCA, 2013, p. 9)

Croca also stresses that «the very existence by itself implies the becoming which results from very complex reciprocal interacting relationship with the other being» (CROCA, 2013, p. 36). Now, notice that «in the physics of Becoming the infinite division, the infinite partition is not possible. In this case the minimum possible division corresponds to the difference between two possible states. [...] From a certain level down of description the being ceases to exist as such.» (CROCA, 2013, pp. 40-41). And add that

> each state is in permanent becoming, that is, this entity is the subject of the change. The wave is primarily characterized by the frequency which stands for the repetition of a given, more or less complex temporal pattern in the continuous becoming. (CROCA, 2013, p. 33)

The above quotes make very tenable the supposition that in contemporary theoretic physics, Whitehead's main attempts to overcome the mechanist image of the world are finding their echoes. In the technical abstraction of physics the notion of frequency, deemed to mean «the repetition of a given, more or less complex temporal pattern» seems to correspond to the occasions' epocal nature, which needs to emerge into the actual plane of existence as an extensive indivisible quantum (WHITEHEAD, 1978, p. 283). Since any actual occasion defines an extensive region both spatially and temporally, neither space nor time are, in their concrete

processes of becoming, mathematical continua. The «cell-theory of actuality» defended by Whitehead (WHITEHEAD, 1978, p. 219) states that the continuity feature of the universe concerns its relational potentiality while the becoming is atomic (Whitehead, 1978, p. 35). But, to avoid misunderstanding, notice that in Whitehead's cosmology «atomism does not exclude complexity and universal relativity. Each atom is a system of all things» (WHITEHEAD, 1978, 36). It seems plausible to feel the resonance of Whitehead's view of any entity as a rhythmical complex pattern springing from its «internal relations» with its actual world with eurhythmic physics. This interacting relationship occurs through the sub-quantum medium – the second assumption of hyperphysics. We can compare this assumption to the Whiteheadian concept of an extensive continuum:

> The second metaphysical assumption is that the real potentialities relative to all standpoints are coordinated as diverse determinations of one extensive continuum. This extensive continuum is one relational complex in which all potential objectifications find their niche. […] An extensive continuum is a complex of entities united by the various allied relationships of whole to part, and of overlapping so as to possess common parts, and of contact, and of other relationships derived from these primary relationships. [...] This extensive continuum expresses the solidarity of all possible standpoints throughout the whole process of the world. It is not a fact prior to the world; it is the first determination of order – that is, of real potentiality – arising out of the general character of the world. In its full generality beyond the present epoch, it does not involve shapes, dimensions, or measurability; these are additional determinations of real potentiality arising from our cosmic epoch (WHITEHEAD, 1978, p. 66).

> […] the perspective of one sub-region from the other is dependent on the fact that the extensive relations express the conditions laid on the actual world in its function of a medium. These extensive relations do not make determinate what is transmitted; but they do determine conditions to which all transmission must conform. They represent the systematic scheme which is involved in the real potentiality from which every actual occasion arises. This scheme is also involved in the attained fact which every actual occasion is. [The] sense in which the world can be conceived as a medium for the transmission of influences has been discussed. This orderly arrangement of a variety of routes of transmission, by which alternative objectifications of an antecedent actuality A can be indirectly received into the constitution of a subsequent actuality B, is the foundation of the extensive relationship among diverse actual entities. (WHITEHEAD, 1978, p.72)

Moreover, as claimed by the third assumption of hyperphysics, it is also true for Whitehead that enduring physical objects are nothing but features of the self-organizing inter-dependent sub-systems of the medium:

> In truth the object in its completeness may be conceived as a specific set of correlated modifications of the characters of all events […] The total assemblage of the modifications of the characters of events due to the existence of an object in a stream of situations is what I call the "physical field" due to the object. But the object cannot really be separated from its field. The object is in fact nothing else than the systematically adjusted set of modifications of the field. The conventional limitation of the object to the focal stream of events in which it is said to be "situated" is convenient for some purposes, but it obscures the ultimate fact of nature. From this point of view the antithesis between action at a distance and action by transmission is meaningless. The doctrine of this paragraph is nothing else than another way of expressing the unresolvable multiple relation of an object to events (WHITEHEAD, 1920, p. 190).

However, what is most important to point out at this moment is the fact that, in both hyperphysics and organicist cosmology, a general evolutionary relationalist ontology leads to understand nature's dynamic forms of order as emergent properties due to the transforming interactions among entities at different scales of observation. As stated by the contingentist metaphysics sketched by Peirce, natural laws are not externally imposed on being but conversely its are existential emergent compromises due to the entities' interactions. On the one hand Whitehead argues that:

> 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. Beyond these societies there is disorder, where "disorder" is a relative term expressing the lack of importance possessed by the defining characteristics of the societies in question beyond their own bounds. [...] The term "disorder" refers to a society only partially influential in impressing its characteristics in the form of prevalent laws. This doctrine, that order is a social product, appears in modern science as the statistical theory of the laws of nature, and in the emphasis on genetic relation (WHITEHEAD, 1978, p. 92).

> The nexus [of actual occasions] "sustains a character", and this is one of the meanings of the Latin word *persona.* But an "enduring object", qua "person", does more than sustain a character. For this sustenance arises out of the special genetic relations among the members of the nexus. An ordinary physical object, which has temporal endurance, is a society. [...] These enduring objects and "societies" analysable into strands of enduring objects, are the permanent entities which enjoy adventures of change throughout time and space. For example, they form the subject-matter of the science of dynamics. (WHITEHEAD, 1978, p. 35)

In one of his latest lectures Whitehead reaffirmed again the absence of any intrinsic necessity of natural laws, which are successively named «habits of nature», «modes of procedure», «ways of behaviour», «average, regulative conditions», «modes of interconnection», «modes of self-expression» depending on the «decision» of the «majority of actualities» (WHITEHEAD, 1938, pp. 211-212). On the other hand Croca says that:

> What we call physics is no more than the description, at the different scales of observation, of the reciprocal interactions among these local more or less stable organizations of the subquantum medium. So, in this sense, time and space are not anymore primary concepts, but only emergent helpful concepts helping us to establish a causal relationship among the diverse interacting organized regions of the subquantum medium. […] natural phenomena, at the different scales of observation, are no more than a reflex of the evolution and interaction of these local stable organizations of the subquantum medium. In this sense physics looks for describing the behaviour of these organized structures and their reciprocal mutual interactions (CROCA, 2010, p. 10).

Indeed, reality is conceived as an ensemble of «physical systems [that] are in permanent interaction modifying therefore the interacting medium and being modified at the same time», thus «it is not possible to derive universal physical laws, that is, universal rules and their consequent universal constants» (CROCA, 2013, p. 16). Thus we arrive at the fourth assumption of hyperphysics, which postulates the internal complexity of every entity, even the most basic. Both of the theoretic efforts that we are analyzing share the critique of classical atomistic doctrine postulating the simplicity of the so-called elementary entities by which reality is constituted. As Whitehead points out, one case of what he calls the «fallacy of the misplaced concreteness», typical of the philosophical tradition, is the confusion between the aimed simplicity of our notions and the astonishing complexity of relationships that lies under the first facts that we truly acknowledge in our experience, the flux of events:

> Suppose we keep to the physical idea of energy: then each primordial element will be an organized 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 [...] This system, forming the primordial element, is nothing at any instant. It requires its whole period in which to 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. (WHITEHEAD, 1948, p. 54)

> Modern physics has abandoned the doctrine of Simple Location. The physical things which we term stars, planets, lumps of matter, molecules, electrons, protons, quanta of energy, are each to be conceived as modifications of conditions within the 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. (WHITEHEAD, 1967, p. 157)

Finally, we arrive at the fifth assumption of hyperphysics, the organizational principle of eurhythmy. This principle, which builds upon the de Broglie *formule du guiage*, is a preliminary and provisional attempt to account for the non-linear feature that complex systems manifest. In Croca's words:

> The principle of eurhythmy concretely states that the acron possesses a kind of extended sensorium, its theta wave, with which it feels the surrounding medium. The acron being immersed in its theta wave moves in a stochastic way preferentially to the regions where the intensity of the theta wave is greater. [...] The principle of eurhythmy states that in nature the complex systems in order to keep existing as such must behave, that is, follow a path that, in average, is the best. […] the principle of eurhythmy states that the complex acron immersed in its theta wave, naturally "chooses" on average the best possible path. (CROCA, 2010, pp. 11, 16 and 33)

As claimed by Croca, and as stressed by Moreira as a philosophical consequence of that principle, we have to acknowledge "an incipient free will" and a "weak teleology" in order to understand the evolutionary and ecological functioning of all natural entities. Moreira summarizes his ontological unification as follows:

> We must note that: 1) if, at the deepest level we are able to speak of, i.e. the quantum level, we admit that natural complex structures are monads that interact among themselves through the θ waves that belong to their complex structure; 2) if we accept the existence of biological evolution as a fact; 3) if we do not admit that life could have emerged as a transcendental action, then we must conclude that θ waves are the inner tool that complex structures at the quantum level use to "communicate" with their ill-defined surroundings, which, associated with the tendency to persist described in the principle of eurhythmy, led them to create new emergent complex structures of a higher level that are able to use more complex means to communicate with their ill-defined surroundings, and so on. […] There are just evolving complex structures guided by a "weak teleology". For us, like Bruno said, matter and spirit are no more than two perspectives of inseparable monads. […] every complex system can "learn", and this "learning" process is strongly connected to the possibility of an evolutionary

> process. This "learning" process is mainly connected to the propensity to persist that every complex structures follows, whatever level it belongs to. (MOREIRA, 2010, p. 299)

Moreira's «metaphysical consequences in Giordano Bruno's way» match Whitehead's criticism of the dualism between *res cogitans* and *res extensa.* On one hand, from his studies in symbolic algebra, Whitehead argued that the mathematical treatment of logical concepts is due to the fact that the concepts also have their own extensiveness (COUTURAT, 1900, p. 340), and on the other hand he deemed any actual entity as having both a physical and a psychical pole, representing respectively the efficient causal connections within past and future and the final internal causation of the actual process of realization. At this point we are able to identify the resonance with Moreira's philosophical developments of eurhythmic physics. In fact, Moreira proposes an ontological unification that enables us, while overcoming the famous quantum mechanics paradoxes, to see the world in a way in which physical and noetic features melt:

> If we maintain a clear ontological distinction between matter and spirit or ideas, we are opening the door to every sort of irrationalism. To defend that ideas are transcendent and not inherent to the world is to half-open the door to the permanent action of God in the world […] The renunciation of the wave-corpuscle dualism leads us to the renunciation of the dualism between body and mind and to the renunciation of the dualism between matter and spirit. (MOREIRA, 2010, pp. 298-99)

> The concept of innate "ideas" is linked to the possibility of the very existence of any complex structure, whatever the level we may consider. Any complex structure exists because it is able to interact with the exterior, to treat the information it gets from that interaction, and to act accordingly. […] This is the process of "learning" associated with the principle of eurhythmy. This transforming interaction is deeply related to the concept of acquired "ideas". When a complex higher-level structure emerges, it carries within it, in its complex structure, innate "ideas" and the acquired "ideas" of the complex lower-level structure. […] It is able to persist exactly because it possesses "ideas" that are now innate to it. Innate "ideas", in the sense considered here, exist from the very beginning of the pre-biological evolutionary process. (MOREIRAa, 2010, p. 296)

The "ideas" referred to above are the *eidos*, the patterns which immanently define the enduring structure of the streams of events. These patterns qualify the «θ waves» in a way quite similar to that by which the «eternal objects» qualify the occasion's feelings. Now, in order to more easily recognize the tuning with what was said before about hyperphysics, in the next quotes taken from Whitehead's *Process and Reality*, please read "interaction" when he speaks

of “feeling”, and please read the “tendency” stated by the principle of eurhythmy when he speaks of “aim”:

> (viii) *The Category of Subjective Intensity*. The subjective aim, whereby there is origination of conceptual feeling, is at intensity of feeling (a) in the immediate subject, and (b) in the relevant future. This double aim – at the immediate present and the relevant future – is less divided than appears on the surface. For the determination of the relevant future, and the anticipatory feeling respecting provision for its grade of intensity, are elements affecting the immediate complex of feeling. The relevant future consists of those elements in the anticipated future which are felt with effective intensity by the present subject by reason of the real potentiality for them to be derived from itself. (WHITEHEAD, 1978, p. 27)

> The philosophy of organism seeks to describe how objective data pass into subjective satisfaction, and how order in the objective data provides intensity in the subjective satisfaction. The word “object” thus means an entity which is a potentiality for being a component in feeling; and the word “subject” means the entity constituted by the process of feeling, and including this process. The feeler is the unity emergent from its own feelings [also named “superject”]; and feelings are the details of the process intermediary between this unity and its many data. (WHITEHEAD, 1978, p. 88)

> According to this account, efficient causation expresses the transition from actual entity to actual entity; and final causation expresses the internal process whereby the actual entity becomes itself. There is the becoming of the datum, which is to be found in the past of the world; and there is the becoming of the immediate self from the datum. This latter becoming is the immediate actual process. An actual entity is at once the product of the efficient past, and is also, in Spinoza's phrase, *causa sui.* (WHITEHEAD, 1978, p. 150)

5. The organicist ontology of rhythmical entities

To remedy «the failure of science to endow its formulae for activity with any meaning» (WHITEHEAD, 1938, 210), the organicist philosophy establishes 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» (WHITEHEAD, 1938, 231-232]. Whitehead suggested looking at the world not as mechanism but as a living and developing organism. Its regions and its fields are its cells, which interactions are its pulsing feelings and its rhythmical expression:

> Thus the primitive experience is emotional feeling, felt in its relevance to a world beyond. The feeling is blind and the relevance is vague. Also feeling, and reference to an exterior world, pass into appetition, which is the feeling of determinate relevance to a world about to be. 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 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. (WHITEHEAD, 1978, p. 163)

The last chapter of *PNK* (1919), entitled *Rhythms*, shows that Whitehead was already considering nature as being alive ten years before *Process and Reality* and almost twenty ears before the last chapter of *Modes of Thought* (1938), rightly titled *Nature Alive*. The concept of «rhythm», according to Whitehead, is not reducible to that of a mere pattern, a mere «object» (WHITEHEAD, 1919, p. 198), but on the contrary is one strictly connected with that of «life»: «The specific recognisable liveliness is the recognised character of the relation of the object to the event which is its situation» (WHITEHEAD, 1919, p. 196). The ingression of an object into an event qualifies the essential «liveliness» of nature. Even when a physical object shows no rhythms in its macroscopic appreciation, following modern science we have to recognize that it is «an average of rhythms which build no rhythm in their aggregation» (WHITEHEAD, 1919, p. 197). Stating that the essence of rhythms is «the fusion of sameness and novelty», of objects and events, of permanence and process, of forms and facts, Whitehead points out the concept of rhythm as being fundamental, something that enables us to overcome the «bifurcation of nature» and the mechanist frame's abstractness. In a way, we can say that the pulsing rhythms are the actualities, the actual occasions that emerge in their ecstatic becoming construct ever more complex societies in which the individual regimes of undulatory activity of each component are interwoven in a sustainable path, eurhthmically creating more durable entities. Life may not be a mystery anymore if we accept its equivalence with the rhythmical feature of natural entities:

> Life is complex in its expression, involving more than percipience, namely desire, emotion, will, and feeling. 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. (WHITEHEAD, 1919, p. 197)

At the same conclusion arrived Croca in his last book: «So, Life, in this broad sense, is like a symphony, evolving in the becoming» (CROCA, 2021, 124).

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Dr. em Lógica e Filosofia da Ciência com uma tese sobre os fundamentos filosoficos da física moderna e o pensamento de A. N. Whitehead, *Ecstăsis Naturae. O Valor Eurítmico do devir natural: Alfred North Whitehead e a Escola de Lisboa* (Aracne 2022); é ainda autor do livro em dois volumes *Transumano* mon amour*. Notas sobre o movimento H+ (Escritos 2015-2019)* (Aracne 2020; Mapa, 2020 e 2021;).