A reinterpretation of Schrödinger's cat according to Ernst Mayr

Quantum linear superposition v/s macroscopic systemicity

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ABSTRACT: The theory of decoherence, provided we accept its validity, *partially* solves the quantum-macro clash as it had been seen few decades before. Namely, the theory of decoherence permits us to understand (better) why a given macro-system, in contrast to the quantum entities that compose it, *does not* superpose simultaneously several possible states. Subsequently, the theory of decoherence *partially* solves the paradox stemming from the *Gedankenexperiment* known as "Schrödinger's cat". In terms of decoherence, it seems reasonable to admit that the feline, independently from any measurement process, is either alive or dead, but never superposes these mutually exclusive states.

On the other hand, the resolution of a second essential aspect of the quantum-macro clash cannot find any help from the theory of decoherence. While now the overall wave packet reduction by the macroscopic environment of each quantum phenomenon manifesting itself at our scale seems quite plausible, the theory of decoherence does not explain from where our macroscopic world – ultimately irreducible to the only quantum axioms and laws – could emerge. In other words, whereas the macro-non-superposition problem seems almost solved, the *supra-quantum emergence problem* entirely persists.

From the (current) perspective of the macroscopic non-superposition problem, Schrödinger's cat perhaps retains only a historical interest .

But in the present paper, we will try to show that in the context of the supra-quantum emergence problem, the "cat" continues to have a specific relevant significance.

On the other hand, it seems commonly admitted that the special status of the "cat" as a representative of *living matter* does not have any intrinsic meaning within the *Gedankenexperiment*. Other antithetical "macroscopic superpositions" such as a broken-intact phial or simply the needle of a measurement apparatus pointing simultaneously upwards *and* downwards would express the same message than the dead-living "cat."

However, here we aim to prove that the living matter status of the "cat", when related to the supra-quantum emergence problem, *does have* – despite its author – an intrinsic signification which the modern philosophy of science generally denies.

Indirectly inspired by certain assumptions of the neo-Darwinian biologist Ernst Mayr denoting that the existence of living matter expresses a key aspect of the supra-quantum emergence problem, this paper is purposed to establish

- **that the efficient elucidation of the supra-quantum emergence problem should have a *formally and experimentally operating* "general systems theory" according to Ludwig von Bertalanffy,**
- **that this "general systems theory" still looking for its own scientificity remains until further notice reduced to a kind of not entirely full scientific "world vision" or "intellectual attitude" commonly called "holism".**
- **that a generally neglected text passage of Schrödinger's article "*Die gegenwärtige Situation in der Quantenmechanik*" containing the "cat" closely anticipates – despite its author and far ahead of time – the fundamental assumption of "general systems theory", i.e. "the whole transcends the 'sum' of its parts",**
- **that the factors ensuring the powerful formal consistence of quantum physics are – except for one determining detail – the same which hamper the creation of a scientifically relevant "general systems theory" and, subsequently, impede the elucidation of the supra-quantum emergence problem.**

0. Inflating intellectual inflation ?

Thousands of pages have been covered about Schrödinger's cat. The result is some danger of inflation.
If we do it in our turn, it is for two specific reasons:
1 ° The many reformulations of the "cat" generally ignore the context of the allegory. Indeed, within Schrödinger's long article*"Die gegenwärtige Situation in der Quantenmechanik"* – 15 pages comprising eachone two columns – the "cat" occupies just 20 lines (Schrödinger 1935, p.812). However, the text combines global inferences – most often overlooked by the current approach of the "cat" – that transcend the single issue of the wave packet reduction on which standard comments are focusing.
2 ° Among these inferences, a certain passage anticipates – despite its author – a topical questioning: the supra-quantum emergence problem. In this paper, we focus on this passage which – rather paradoxically and and far ahead of time – immediately suggests the founding assumption of the "general systems theory" still looking for its scientific status (cf. below).

Let us try now to identify the exact issue of this paper, a problem which, at first glance, might seem frankly disjointed in a quantum context.
As we all know, the fundamental assumption of the above mentioned general systems theory reads as follows: "The whole transcends the 'sum' of its parts." Many facts directly accessible to our intuition – we will come back later to this point – indicate the validity of this assertion. Yet it is far less certain that the assumption in question can really be the starting point of a scientific approach mastering all aspects of the macroscopic world that effectively require a *systemic* approach worthy of the name. We must recognize that the so-called discipline seems more similar to a world vision than to a strictly scientific edifice.
It is now interesting to note that Schrödinger's famous article containing the "cat" includes – unintentionally, as it must be repeated – some inferences that closely look alike the fundamental assumption of general systems theory.
Specifically, these inferences express a sort of antisymmetry with respect to the systemic assumption; a particular antisymmetry which summarizes in our view the main problem undermining the scientific character of the general systems theory. On this basis, we will attempt to establish that the factors hindering until further notice general systems theory from accessing to a full scientific activity status overlap closely with the roots of the supra-quantum emergence problem, roots illustrated by the "cat" covered under the light of its original epistemological context. On this occasion, we will see how the factors that, despite or perhaps because of their essentially non-intuitive appearance, ensure the consistency of quantum physics, are – except for one strongly determining detail – the same that impede the establishment of a really operating "general systems theory."
On the other hand, biology, by the essentially systemic nature of its investigation fields, 1° aspires literally to the possession of a truly operational general systems theory and 2° expressed a particularly acute form of the emergence problem. Thus we hope that our reinterpretation of the "cat" according to Ernst Mayr – we return to this point a few lines below – brings some light on the epistemic horizon that quantum physics encounters when a given investigation moves from the subatomic scale to the *organized* macroscopic world and its *illusory* familiarity.

N.B. We would like to clarify that this paper does not express the slightest claim to "solve" or "found" anything. We are just trying to understand a little better the emergence problem whose only formulation is far from being unanimous. Schrödinger's assertion – while coming from very different backgrounds – denote a manifest / formal antisymmetry between the quantum problem treated by the author and the essentially macroscopic "systemic postulate," and this offers an additional renter – nothing more – to elucidate the fastidious supra-quantum emergence problem, a major theme of modern philosophy of science.

0.1 Some preliminary terminology indications: "holism" and "general systems theory"

The expression "general systems theory" belonging to the key words of this paper leads to confusion with the concept "holism" rather present in the jargon of modern epistemology. Indeed, both terms "general systems theory" and "holism" are 1° referred to the above mentioned postulate "The whole transcends the 'sum' of its parts" (Healey 2009) and 2° opposed to "reductionnism" (*ibid.*). Despite of this close resemblances, "holism" and "general systems theory" are *not* identical. From our standpoint, "holism" denotes 1° the awareness that for a certain category of systems "the whole is more than the sum of its parts" and 2° an intellectual ("metaphysical", methodological …) *attitude* (*ibid.*) according to this awareness. By contrast, a general systems theory *should* be the formal and experimental framework of a positively scientific investigation of systems which are concerned by the systemic postulate. Facing enormous difficulties, general systems theory – in our view – has not been able to go beyond the stage of a project. But its vocation is to become an entirely scientific edifice.
For touching to this aim, implemented researchers have to recognize and analyze all these factors which are manifestly hampering the access of general systems theory to full scientificity. The present paper would be a contribution to this global approach.
Let us still add that we mean by "systemicity" the quality of a system to be affected by a whole transcending the 'sum' of its parts.

1. Starting point considerations

1.1 The supra-quantum emergence *problem*

The quantum world is supposed to "found" the macroscopic world. However, nowadays, it seems widely accepted that the macroscopic world has aspects that are irreducible to the axioms and laws of quantum physics.
Certainly, it would be rash to assert positively that the macroscopic world *is* somehow "suspended above" the quantum world. The level of controversy revolving around the idea of a "self-supporting reality" and many other conceptions entering in this area (Costa de Beauregard, 1998), is sufficient to inspire us some hesitation before we would assert anything in this field. On the other hand, Serge Haroche, a major figure in the theory of decoherence, states that the study of macroscopic complexity, rather independent of the underlying quantum data, often makes emerge new effects (Haroche, 2004, p. 38). Finally Michel Bitbol (Bitbol, 2008, p. 138) evokes phenomena – specifically interactive structures – we can only understand as "the effect of emergence in our level of organization" (cf. below).
Anyway, out of caution, taking into account the uncertainty proper to this area, we call "supra-quantum emergence *problem*" the central issue of this communication without taking a position on the "existence" or "reality" of emergence.

1.2 Reinterpretation according to E. Mayr

Now let us turn to the biologist Ernst Mayr, a leading figure of contemporary neo-darwinism. In a book with a suggestive title (Mayr, 2006; see also Mayr 1997), Mayr describes biology of as a "science like no other." According to the author, much specific biological knowledge is not reducible to more fundamental scales accessible to physics. Biological research, when

facing essential questions about 1° the appearance of living matter from inert matter and 2° the evolution of living matter from its most primitive forms to the human central nervous system, according to Mayr, finds no help from quantum physics (Mayr, 2006, p.23).
It would never occur to anyone's mind to suspect this researcher of having "creationist," "vitalist" or some other mystical sympathies. On the other hand, it can be legitimate for a biologist to ignore the problem of emergence and create models that consider the evolution of complexity assumed as such, without attempting to reduce it to a more fundamental level. This biologist proceeding has some similarities with the view a sociologist who, interested in social fact, legitimately ignores the laws governing all this quantum particles that the individuals constituting the society have "in them."
Mayr (op. cit. p. 68 ff.) argues in this way that biology is faced with macroscopic *emerging* situations and defines these as the occurrence of properties within a given system that do not appear manifestly in the components of which the global system is consisting. The author (*ibid.*) adds that this view, now purged of metaphysical overtones which formerly accompanied it, is nowadays generally accepted by the scientific community. (see also Mayr 1997, p.32.; comp. Licata, 2009, pp. 4.ff.; Butterfield, 2010, pp.4ff.;p.7; pp.8ff. pp.11ff.; pp.19ff.;pp.26ff.; comp. Butterfield, 2011, pp.4ff; pp.11ff.; pp.26ff.; pp.42ff.; Butterfield and Bouatta, 2011, p.3, pp.19ff., Kuzemski 2012, pp. 6 ff. *passim*; Wallace, 2011-b, p. 10; comp. Fields, 2012, pp.6 ff.)
However, a physicist interested in quantum level should consider unsatisfactory the idea that the macroscopic scale to which he and his brain belong, is seen as a sort of alien planet against his field of research (comp. Bitbol, 2010, pp.2ff.).
Without falling into reductionism which is not our scope, we *have* to assume the following question: How can we explain the occurrence of "familiar" macroscopic phenomena such as the presence of living matter if those are not reducible to the fundamental quantum laws? *Until this question does not have a relevant answer, the appearance and evolution of living matter form the core of the emergence problem*.
Thus our reading of the " 'cat' according to E. Mayr" gradually is becoming clear: Contrary to what is generally stated, the *presence of living matter* within Schrödinger's Gedankenexperiment *has a specific meaning*, even if its author had certainly not thought of it. This is the subject of the next section.

2. Beyond the current debate revolving around the "cat"

2.1 Some aspects of the traditional debate

The debate revolving around Schrödinger's cat traditionally focuses on the wave packet reduction problem. Since the Schrödinger equation

$$i\hbar\,(\partial\Psi/\partial t) \;=\; (\hbar^2/2m)\Delta\Psi + V\Psi \qquad (2\text{-}1)$$

superposes a multitude, or more precisely a spectrum of possible states $|\Psi(t)\rangle$ where just one state $|\Psi^*(t_0)\rangle$ is "realized" through the process of observation, or, if preferred, through the measurement performed at t_0, it "should" be the same for all macro-systems lastly composed of particles governed by (2-1); macro-systems we write temporarily (see below / section. 3.3) in the form of an n-tuple of functions $(\ldots,\Phi_i,\ldots)$ which n variables Q_j, such as

$$dQ_i / dt = \Phi_i(\ldots, Q_j, \ldots, t),\;\; i, j = 1,2, \ldots n . \qquad (2\text{-}2)$$

The current / traditional debate turns one way or another around the question, why macro-systems *do not* "superpose" eachone several states (..., Q_j, ..., t) that only the act of measurement involved in t_0 would reduce to a single state (…, Q_j^* , …,t_0). From this perspective, the "living-dead cat" is a antinomy among others and could be replaced by a device without living matter, such as a intact-broken phial (see below, section 2.2.).
As regards the wave packet reduction problem, its elucidation has significantly advanced. While in 1965, B. d'Espagnat still had written that there was no physical knowledge able to explain objectively the discontinuity between the macroscopic and quantum worlds (d'Espagnat 1965, p. 91), the theory of decoherence, in particular, makes us now understand (better) why, unlike the quantum superposition of a multitude of potential states $|\Psi(t)>$, macroscopic (..., Q_j, ..., t) systems governed by an n-tuple of functions (…,Φ_i ,…) represents in each moment t_0 an unique physically significant state (…, Q_j^* , …,t_0) of the macro-system being supposed to extend the underlying quantum entity, and not a superposition of several states (Zurek, 1991, esp. pp. 5 ff. Bächtold, 2008, p. 78 ff.).
Of course, together with the experimentally substantiated theory of decoherence (Haroche, 2010-b)), other approaches such as the pilot-wave theory the spontaneous localization theory, the theory of multiple universes and even of multiple minds have been advanced. Leaving aside any question of intrinsic validity of these approaches (for discussion, cf. Field, 2012; Rosinger, 2009, Wallace, 2011-b; Zeh, 1999), let us nevertheless point out their ultra-speculative character which coupled with a manifest lack of consensus underscores the absolute magnitude of the epistemological uncertainty still prevailing in this area (Bächtold, 2008, p. 85 ff.). Within this ocean of quicksand, the theory of decoherence appears to be a very solid rock.
Thus, in this paper, we accept the hypothesis that the theory of decoherence explains exhaustively the non-superposition of potential states in macroscopic systems. In other words, the theory of decoherence explains why it seems reasonable to assume that a macroscopic system occupies at an instant t one single state instead of superposing several states. From the standpoint of the theory of decoherence, it is not surprising that a cat – although consisting of quantum entities – does never superpose the two states "death" and "living." Only from the perspective of the traditional dead-living antinomy problem, Schrödinger's cat, henceforth, would not have more than historical interest.
Yet the "cat" remains entirely topical since *its scope is not limited to the single dead-living antinomy*.
Despite the foregoing, the theory of decoherence does not solve *fundamentally* the wave packet reduction problem, or, if preferred, the measurement problem. Indeed, the theory of decoherence does not explain in any way the manifest existence of a macroscopic world whose characteristics do not all arise from the only quantum axioms and laws. In other words, the theory of decoherence does not provide a solution for the macroscopic emergence problem. Now, decoherence is itself an emergent phenomenon. (Wallace, 2011-a, pp. 12, 16,17). Therefore, solving the wave packet reduction problem by the theory of decoherence would be tantamount to solving the emergence problem by the emergence problem (*ibid.*) !
It is at this level that the *presence of living matter* in Schrödinger's thought experiment plays an essential role.

2.2 Why a "cat"?

To better understand this last point and its links with a reinterpretation of the "cat according to E. Mayr", let us turn to a seemingly pointless question: Why a cat? Instead of providing a cat supposed to "superpose" until a given observation or measurement act two antithetical states | dead> and | alive>, the *Gedankenexperiment* could be satisfied with a much simpler

device, for example a fragile vase “superposing” the states | broken> and | intact> .
In fact, the only phial in Schrödinger’s assembly which, even without its cyanide, “superposes” the same states | broken> and | intact>, would also enable the device to fulfill its mission.
It should be pointed out that in absolute terms, we might forget the broken-intact phial as much as the living-dead cat. A needle indicating “after measurement” the values 0 or 1, but which is supposed to “superpose” – “before measuring” – the two values 0 (up) and 1 (down), would in turn be sufficient. Indeed, d'Espagnat, saying that the adressed problem “is also known as Schrödinger’s cat” proposes such a needle assembly, without any animal presence (d'Espagnat 1994 p. 174 ff.; comp. Wallace 2011-b, pp.5 ff.).
In short, the “cat” itself seems basically useless. Perhaps its presence was mainly motivated by “stylistic” reasons. The article “*Die gegenwärtige Situation in der Quantenmechanik*” has the vocation to reinvigorate a debate. According to d'Espagnat (op. cit. p. 174), maybe Schrödinger wanted “to capture our imagination.” Bricmont (Zwirn & Bricmont, 2009, p.7) thinks the cat would be here “to make things more dramatic.” Anyway, the staging of the feline and all the discussions revolving around it have “popularized” the wave packet reduction problem (Bitbol 2008, p. 244 and 401). Finally, the polemical context of the Gedankenexperiment could justify a (small) dose of provocation.

Yet we will see now that in our context, the “cat” and even the phial *do have* their *intrinsic* meaning contrasting with the needle assembly. For the moment, we keep the three assemblies “cat,” “phial without cat” and “needle”. Let us denote by | 1> and by | 0> the two equiprobable superposed states of the particle which, according to its disintegration or non-disintegration, trigger or not trigger – via an amplifier device – the destructive process characterising the *Gedankenexperiment*. Depending on the chosen assembly: « needle », « phial » or « cat », we adopt the following conventions regarding the possible outcomes of the experiment: the symbols | ↑ > and | ↓ > mean “needle pointing upwards” and “needle pointing downwards”. For the phial, we keep the items | broken>, | intact>, and for the cat | dead >, | alive >.
The expressions (2-31) (2-32) (2-33) (where Ψ denotes the wave function of the particle to be or not to be disintegrated, and Ψ' the overall wave function describing (??) the macro-components (needle, phial, “cat”) of the system)

$$|\Psi\rangle = 1/\sqrt{2}\,|1\rangle + 1/\sqrt{2}\,|0\rangle \quad (?)\Leftrightarrow(?)$$
$$(?)\Leftrightarrow(?) \quad |\Psi'\rangle = 1/\sqrt{2}\,|\uparrow\rangle + 1/\sqrt{2}\,|\downarrow\rangle \qquad (2\text{-}31)$$

$$|\Psi\rangle = 1/\sqrt{2}\,|1\rangle + 1/\sqrt{2}\,|0\rangle \quad (?)\Leftrightarrow(?)$$
$$(?)\Leftrightarrow(?) \quad |\Psi'\rangle = 1/\sqrt{2}\,|\text{broken}\rangle + 1/\sqrt{2}\,|\text{intact}\rangle \qquad (2\text{-}32)$$

$$|\Psi\rangle = 1/\sqrt{2}\,|1\rangle + 1/\sqrt{2}\,|0\rangle \quad (?)\Leftrightarrow(?)$$
$$(?)\Leftrightarrow(?) \quad |\Psi'\rangle = 1/\sqrt{2}\,|\text{dead}\rangle + 1/\sqrt{2}\,|\text{living}\rangle \qquad (2\text{-}33)$$
'

seem equivalent and *are* equivalent to a certain extent. *But not in absolute terms*. Before getting there, we must first clarify that in the expressions (2-31) (2-32) (2-33), the kets on the right of the “dubious equivalence” symbol (?)⇔(?), i.e. | ↑ > and | ↓>, | broken> and | intact>, | dead> and | alive>, may be *abusive*. The fact that microscopic and macroscopic entities are coupled in a global system, there is no problem. But this is not necessarily a sufficient reason to authorize the extension of quantum writing | Ψ> to the macroscopic components of the overall system, whether it be a cat or a phial or a needle or anything. All issues of the current debate revolving around the Gedankenexperiment converge on this problem. (Compare Bächtold, 2008, p. 67 ff.; H. Zwirn in d'Espagnat 1998, pp.270 ff.; also Zwirn & Bricmont, 2009, p. 6).

But beyond this debate, new questions arise. If the expressions (2-31) (2-32) (2-33) have a common feature, in our context the risk of illegitimate kets right of the symbol (?)⇔(?), if (2-31) (2-32) (2-33) are *equivalent in this respect*, other factors make that their conditional equivalence disappears. It is at this level that the specific meaning of the "cat" – and incidentally of the phial – manifests itself, in contrast to the *very different case* – as we will see – of the needle assembly according to B. d'Espagnat.
Thus let us return to the *apparently* useless "cat" in the Schrödinger device, but which is in fact highly significant.
Note, however, that it is out of question to attribute to Schrödinger intentions he never had. The intrinsic/specific meaning that we give to the "cat" as a *representative of living matter* is beyond Schrödinger's aims.
Nevertheless we have to point out that d'Espagnat proposes a customized version of the "cat" on the basis of an assembly comprising "living-dead experimenters" (d'Espagnat 1965, p. 127 ff.), without mentioning any specific role of living matter. Yet again, despite the author, living matter *has* a specific role in our context.

2.3 Back to a reinterpretation according to E. Mayr

Now let us recall the position of the biologist Mayr stating that the investigation 1° of the appearance of living matter from inert matter and 2° of the evolution of living matter leading to the human central nervous system finds no help from quantum physics. Intuitively speaking, living matter expresses – in terms of Mayr – the most glaring aspect of the supra-quantum emergence problem.
While nobody would seriously argue that the elucidation of inert matter "has no debt to quantum physics", Mayr's position relating to living matter, despite its peremptory accents, deserves a substantive analysis. On this occasion, we will find that the scope of the "cat" – not at all limited to the wave packet reduction issue – can address the supra-quantum emergence problem from a different angle.

3. Quantum linearity, macro-nonlinearity and "trans-linearity"

3.1 The limited scope of the needle assembly

A first observation is glaringly evident: Whatever the outcome of the needle assembly, the experiment keeps intact the *state of order* being inherent in the macroscopic part of the system. Regardless of whether the needle, at the end of the process, tips up (↑) or down (↓), the *state of order* characterizing the macro-display device *is not affected*.
However, for the "phial" and "cat" assemblies, the situation is quite different. Each time the potential outcome | 1> (disintegration of the particle) is realized, the macro-component of the overall system ("phial" or "cat") *undergoes the transition* "*order → disorder*."
In other words, the macro-component of the needle assembly belongs to the narrow category of ideally reversible systems, while the macro-components of the "phial" and "cat"

assemblies are inherently affected by the experimental process, expressing *irreversibility* in the sense of the Second Law of Thermodynamics. In philosophy of physics, the head-on clash between reversibility and irreversibility traditionally brings trouble, and the present case is not an exception to the rule. It is a delicate navigation between the pitfalls of irreversibility which will allow us to go further.

3.2 Irreversibility beyond "classical" non-linearity

3.21 Quantum linearity, delinearization of the micro-macro linkage, "trans-linearity" of the first kind

When we compare the expression (2-1), i.e. $i\hbar\,(\partial\,\Psi\,/\,\partial\,t) = (\hbar 2/2m) + \Delta\Psi\ V\Psi$, which governs the authentic kets | Ψ>, 1/√ 2 | 0> and 1/√ 2 | 1> given in (2-31) (2-32) (2-33), to the n-tuple of functions $(...,\Phi_i, ...)$ which determines through the expression (2-2) , i.e. $dQi / dt = \Phi_i\ (..., Qj, ..., t)$ the evolution of macroscopic systems including abusive kets | ↑> and | ↓>, | intact> and, to some extent, | living >, (but not | broken > or | dead >; see below), our basic intuition tells us that we move "from one world to another one, fundamentally different." But if we want to go beyond this intuition in order to obtain a somewhat further elucidation, increased efforts of conceptualization are required.

As we know, the quantum world governed by (2-1) is basically linear. Indeed, the principle giving to the state space **E** of any quantum system in the form of vector space, so that for any $|\Psi_1>$ and $|\Psi_2>$ belonging to **E** and for any complex λ_1 and λ_2

$$\lambda_1|\Psi_1> + \lambda_2|\Psi_2> = |\Psi_3> \in \mathbf{E}\,, \qquad (3\text{-}1)$$

this principle is a postulate of quantum physics, without which the building would collapse. (Note however that according to Jean Bricmont (Zwirn & Bricmont, 2009, p. 27), this point, in absolute terms, could be challenged. In order to avoid further complications in the present issues, we will come back to this point a little later). But, anyway, despite their *fundamental* linearity, quantum systems, broadly speaking, are not frozen in a rigid linearity. The phenomenon of superposition of linearities is *ipso facto* a kind of delinearization of the system (see below). On the other hand, under the interpretation of the Schrödinger equation by Max Born, the probability ℘ to find for an observable A of the system occupying the state | Ψ > , the eigenvalue a_n of A, is nonlinear: Expressing | Ψ> in an eigenbasis **u** of A belonging to **E**, i.e. $|\Psi> = c_1|u_1> + c_2|u_2> + \dots c_n|u_n> + \dots\dots$, the probability ℘ of finding the value a_n for A is written $\wp(a_n) = |c_n|^2$.

Suppose now that a given quantum system occupies the possible state $|\Psi_1>$, with the probability $\wp_1(a_n)$ to find for the observable A the value a_n. Let $\wp_2(a_n)$ be the probability of finding the same value for A when the system occupies another possible state $|\Psi_2>$. Moreover, since the two states $|\Psi_1>$ and $|\Psi_2>$ are possible, the state $|\Psi_3> = |\Psi_1> + |\Psi_2>$ is it too. Yet the probability $\wp_3(a_n)$ to find for A the value a_n when the system occupies $|\Psi_3>$ is obviously not equal to the sum $\wp_1(a_n) + \wp_2(a_n)$. Under $\wp_3(a_n) = |c_{1n} + c_{2n}|^2$, an "interference term" equal to $2\,c_{1n}\,c_{2n}$ differs $\wp_3$ from the sum $\wp_1(a_n) + \wp_2(a_n) = |c_{1n}|^2 + |c_{2n}|^2$ This "interference term" represents an absolutely common nonlinearity giving to quantum mechanics the necessary flexibility to harmonize the ultra-linearity characterizing the

expression (3-1) and the measurement act recorded in our macroscopic world where the idea of reducing all phenomena to fundamental linearity would be meaningless.
While the "interference term" thus belongs to absolutely classical nonlinearity, this is not the case for the quantum superposition *coupled* to the Born interpretation of the Schrödinger equation. A classical nonlinearity involves determined quantities (numbers, vectors, tensors ...), and *not* the superposition of such quantities.
Let us call "trans-linearity of the first kind" this *coupling* of quantum superposition of linearities $\Sigma(\lambda_n|\Psi_n>)$ and probabilities $\wp(a_n) = |c_n|^2$. This qualification which at first may appear useless and even a bit far-fetched, will subsequently take in our context an essential meaning.

3.22 Macro-irreversibility beyond "classical" nonlinearity

At the macroscopic scale, phenomena which are reducible to linearity, instead to hold a monopoly of fundamental formalization such as we find it at the quantum scale *before* the *macro-involved* measuring act, belong quite the opposite to the category of particular cases.
Certainly, the expression (2-2), $dQ_i / dt = \Phi_i(\ldots, Q_j, \ldots, t)$ can sometimes have linear solutions. Let us return to our abusive ket | intact> describing the state of the phial in Schrödinger's assembly, every time the object had escaped the fatal outcome. As the material points composing the phial do not move, the expression (2-2) becomes

$$\forall i \in \{1, 2, \ldots n\},\ dQ_i / dt = \Phi_i(\ldots, Q_j, \ldots, t) = 0. \qquad (3\text{-}2)$$

This then allows us to write – in this extremely restrictive case, rightly described as "trivial" – for any Φ_i and at any time t:

$$\lambda_k\Phi_k + \lambda_l\Phi_l = \Phi_m \in (\ldots, \Phi_i, \ldots,) \qquad (3\text{–}11)$$

and establish in this way a kind of formal analogy between (3-1) and (3-11). By postulating further that the theory of decoherence solves significantly the wave packet reduction problem emerging when passing from (3-1) to (3-11), we would get a "quasi-harmony" between both quantum and macroscopic levels combined in the Schrödingerian phial assembly without cat.
But the passage from this frozen ultra-linearity to a some less rigid linearity such as $dQ_i / dt = \Phi_i(\ldots, Q_j, \ldots, t) = 1$ already would disturb our quantum / macroscopic quasi-harmony in terms of macro-overdetermination.
Now, we do not intend to go in for easy caricature.
The preceding remarks have no other purpose than to highlight the deep chasm between the soft versions of the *Gedankenexperiment* – replacing the feline by some inert matter – and its original configuration with highly organized living matter.
If the presence, at the macroscopic scale, of a "mixture" comprising linearities and nonlinearities already joins the problem of a supra-quantum emergence "above" the fundamental linear scale, this problem becomes frankly more serious when we pass to *living matter* whose exhaustive description, in all cases essentially nonlinear, transcends in fact the only issue of classical nonlinearity.

This point requires some explanation.
A living organism, to survive, must ensure that some of its main functions approach equilibrium. These functions closely approach, at least for some time, the ultra-linear expression $dQ_i / dt = \Phi_i (\ldots, Q_j , \ldots,t) = 0$. But, in order to preserve this equilibrium, the n-tuple of functions $(\ldots,\Phi_i ,\ldots)$, because of *macroscopic irreversibility*, is necessarily included in a m-tuple of functions $(\ldots,\Phi_i , ..., \Phi_k ,\ldots)$, , m > n, knowing that this larger system is systematically nonlinear. Ludwig von Bertalanffy (von Bertalanffy 1993, p.164) mentions in relation to homeostasis the phenomenon of *Fließgleichgewicht*, i.e. a partial equilibrium maintained by a *flow* of energy and/or matter.
This (*classical*) nonlinearity is not the monopoly of living matter, but the latter, as experience shows us, could not evolve in a physical world reduced to strict linearity. However, living matter essentially develops properties located *beyond* the "classical" nonlinearity, knowing that this case is very different from trans-linearity of the first kind expressed by coupling quantum superposition of nonlinearities $\Sigma(\lambda_n|\Psi_n>)$ and probabilities $\wp(a_n) = |c_n|^2$.
In order to address *gradually* this new issue beyond "classical" nonlinearity, let us return to one of the possible substitutes replacing the living-dead cat, in this case the phial which is intact or broken at the end of the experiment. For the moment, we assume that the first possibility is realized. As the object remains intact, nothing prevents us, as we stated above, to describe the "evolving" of the "system" by the expression $dQ_i / dt = \Phi_i (\ldots, Q_j , \ldots,t) = 0$. Despite its somewhat caricatural aspect, the n-tuple of functions $(\ldots,\Phi_i ,\ldots)$ *does have* a meaning. In contrast, when the experiment ends badly for the flask, the n-tuple of functions $(\ldots,\Phi_i ,\ldots)$ *vanishes* and its meaning with it, which would not be the case for a needle device.
Now we forget the Gedankenexperiment itself, its challenges and epistemological controversies. We suppose that at the instant t *, the phial stupidly falls out of our hand and breaks on the floor. In t *, the system expresses a transition

$$(\ldots,\Phi_i ,\ldots) \quad \rightarrow \quad \text{non}(\ldots,\Phi_i ,\ldots) \tag{3-3}$$

representing "something more" than the "simple" passage from linearity to nonlinearity. By this "something more" – the general "order → disorder" transition of *macroscopic irreversibility* – we barely touch on the problem we are focusing on; a problem taking its full extent in the context of living matter. This is the issue of the next section, where we will find the expression (3-3) as a special case of a wider expression representing an attempt to formalize the evolving of a highly organized system such as living matter.

3.3 The trans-linearity of the second kind; *evolving organization* of macroscopic phenomena

Now we return to the "cat", or to any equivalent living organism. Obviously, such an *evolving organization*, during the time interval from birth to death, can not be governed by a single $(\ldots,\Phi_i ,\ldots)$, i = 1, ...n remaining the same to itself. Quite the opposite, it seems reasonable to admit that the number n of functions involved in the process increases over time, and then decreases until the final phase described closely by (3-3). Assuming, in the absence of any more appropriated solution, the discontinuity of a sequential writing, extremely narrow when faced with the specific continuity of such a process, we try now to formalize somehow the vital – ontogenic – evolution of the "cat" or any other equivalent living organism in the following terms:

$$
\begin{array}{c}
(\ldots,\Phi_{1i},\ldots),\ \ i = 1, \ldots n_1 \\
(\ldots,\Phi_{2\,i},\ldots),\ \ i = 1, \ldots n_2 \\
\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\
(\ldots,\Phi_{u\,i},\ldots),\ \ i = 1, \ldots n_u \\
\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\
(\ldots,\Phi_{i^*},\ldots),\ \ i = 1, \ldots n^* \ \rightarrow\ \mathrm{non}(\ldots,\Phi_i,\ldots)
\end{array}
\qquad (3\text{-}4)
$$

Passing over time from a n-tuple of functions $\Phi_{u\,i}$ to another, the variation in the number n of functions $\Phi_{u\,i}$ change for some of these their meaning. This change of meaning can be expressed – among other possibilities – by the splitting of the concerned functions in finer ones or by the grouping of several functions in a single item. Specially in this last case we must consider the founding assumption of the general systems theory "the whole transcends the sum of its parts." At this level, we encounter synthesis phenomena in the Hegelian sense: The grouping of several $\Phi_{u\,i}$ can make emerge one Φ_{vj} where we do no longer recognize the original functions $\Phi_{u\,i}$. We have to point out that a given function $\Phi_{u\,i}$ belonging to the "step" $(\ldots,\Phi_{u\,i},\ldots)$ of the considered evolution does not necessarily retain its meaning in a later stage $(\ldots,\Phi_{u\,i},\ldots)$ marked by the emergence of new $\Phi_{v\,i}$ and / or by the disappearance of other ones.

It is clear that the the ontogenic evolving of a cat or dog or whatever considered over the time interval beginning with the birth of the animal and ending with its death expresses, broadly speaking, a very particular form of nonlinearity. Indeed, the "classical" nonlinearity, provided that we choose sufficiently small reference intervals , lends itself to more or less acceptable linear approximations. At the infinitesimal level the approximation "nonlinearity → linearity" even tends to accuracy.

In contrast, when we are facing an evolution as described – for better or worse – by the expression (3-4), any attempt to treat this *special* nonlinearity by an approached linearity referred to sufficiently small intervals would *miss the point*. It seems already hard to find a "linear approximation" of the final transition of (3-4), namely $(\ldots,\Phi_{i^*},\ldots),\ i = 1, \ldots n^*,\ \rightarrow\ \mathrm{non}(\ldots,\Phi_i, \ldots.)$, just as it would be rather cumbersome to define an "approximative linearization" of the transition "intact phial → shattered phial".

With regards to the intermediate steps $(\ldots,\Phi_{u\,i},\ldots),\ i = 1, \ldots n_u$ of the considered evolution, the intervention of the concept "Hegelian synthesis" which is impossible to formalize exhaustively in terms of classic nonlinearity, sums up the magnitude of the epistemic void affecting an infinity of phenomena belonging – such as the ontogenic envolving of an ordinary cat or dog – to our theoretically familiar daily life. Let us call "trans-linearity of the second kind" the category of situations tentatively described by the expression (3-4).

3.4 A first reformulation of the supra-quantum emergence problem

The introduction of the concept "trans-linearity of the second kind" allows us a first conclusion: While the fundamental linearity of the quantum level finds at the macroscopic scale some narrow but physically meaningful formal analogies – interpreted by linear

phenomena and even by classical nonlinear phenomena suitable for locally linear approximations, the essentially macroscopic trans-linearity of the second kind does not express any analogy with the subatomic scale.
On the other hand, there is no intrinsic link between trans-linearity of the second kind and the trans-linearity of the first kind expressed by the coupling of quantum superposition and probabilities $\wp(a_n) = |c_n|^2$. As such, the trans-linearity of the second kind lies in the heart of the supra-quantum emergence problem.
Since living matter expresses – regarding ontogeny (and phylogeny) – this trans-linearity of the second kind in a particularly striking manner, the "cat" has, certainly inspite of its author, an intrinsic meaning – "according to Mayr" – within the Schrödingerian *Gedankenexperiment*.

3.5 (Appendix) And if the linear Schrödinger equation were just an approximation of a more fundamental nonlinear one ?

3. 51 The Penrose-Bricmont hypothesis

Let us forget – but in the very short term – this trans-linearity and return to the conflict between the essentially linear Schrödinger equation and the macroscopic world marked by "classical" nonlinearity. In this regard, Jean Bricmont, discussing Bell's theorem (this subject does not belong to our present investigation), advances a suggestive hypothesis (Zwirn & Bricmont, 2009, p.27): Since nonlinearity (we add "classical") is manifest at the macroscopic scale, the solution could be a modification of the Schrödinger equation in terms of nonlinearity. Bricmont refers to Penrose: According to the latter, it could not be excluded that the Schrödinger equation will one day be relegated to the status of an approximation within a wider and finer nonlinear quantum theory, just like Newton's theory of universal gravitation becomes a local linear approximation within general relativity.
Although such a (classical) nonlinear extension of the Schrödinger equation is not for tomorrow (ibid.), let us suppose that this "project" will be achieved. Then the conflict between fundamental quantum linearity and classical macroscopic nonlinearity perhaps could be solved. Perhaps.
But what about trans-linearity which, although very poorly defined and formalized, occurs throughout the ontogeny of any cat or dog?
Let us assume that a future nonlinear post-Schrödingerian equation – hypothetical until further notice – determines the position of "all particles of a *living* cat" (op. cit. p.29). Consider now that the cat, initially living, dies because of a serious disturbance affecting the global positioning of its "particles". A new "demon" (comp. Healey, 2012, p.11) added to the very abundant pandemonium characterizing contemporary epistemology, in short, a "demon" able – thanks to the hypothetical nonlinearized Schrödinger equation – to reposition properly the particles of the cat, could he bring the animal back to life? Yes? No? It seems hazardous to adopt a definitive position on this subject.
And can we really be sure that such a nonlinearized Schrödinger equation could control the evident trans-linearity characterizing phylogeny, or, in other terms, biological evolution, without which neither the "cat" nor its commentators would be here?

3.51 In order to avoid a potential misunderstanding

When we evoke the *fundamental* linearity of the quantum level, we think only to the Schrödinger equation which is linear until further notice.
In recent years, quantum research obviously has initiated several approaches qualified as

nonlinear. But this is not necessarily a challenge to the linearity of the Schrödinger equation as such. The most solid approaches among these investigations, that is to say the less hypothetical/speculative ones, generally seem focus on the interaction of fundamental quantum phenomena and their environment located at the *frankly* macroscopic level, or at the atomic or molecular scale where decoherence effects are already occurring. M. Lewin's researches, for example are devoted to nonlinear quantum models concerning electrons in molecules and a mountain pass lemma modelling adiabatic reactions in the Schrödinger time-independent framework (Lewin, 2004). M. Krawiec and K. I. Wysokiknski are studying "thermoelectric phenomena in a quantum dot asymmetrically coupled to external leads" (Krawiec and Wysokiknski, 2008 ; comp. Butterfield and Bouatta, 2011, p.9). Let us add an investigation which is particularly evocative in this context: *Classical to Quantum Transition of a Driven Nonlinear Nanomechanical Resonator* (Katz, Retzker, Straub, Lifshitz, 2007). Certainly, Nattermann seeks to transcend these approaches related to a "semi classical" framework but finally recognizes several difficulties seemly insurmountable for the moment (Nattermann 1997). Finally Abram and Lloyd, working on the application of quantum nonlinearity to the quantum computer explicitly state out that "such nonlinearity is purely hypothetical: all known experiments confirm the linearity of quantum mechanics to a high degree of accuracy." (Abram and Lloyd, 1998)
Fundamental linearity as it is mentioned in this paper concerns the ultimate quantum scale *before reduction.*

3. 52 Perspectives

In absolute terms no one can know whether the Penrose-Bricmont hypothesis as given above will be confirmed in the future. However, even if one day the current form of the Schrödinger equation is reduced to be an approximation of a finer approach, that would not change much in our context. In this hypothetical case, the undeniable success of the "traditional" Schrödinger equation would prove *ipso facto* that this linear approximation of a new quantum nonlinearity is *overall* a "good" one. However, at the macroscopic scale, there is no other "good" or even "just acceptable" linear approximation of nonlinearity than its very *local* linearization.

And let us reaffirm that in our context, we have to oppose linearity not so much to classical nonlinearity, but rather to the trans-linearity of the second kind.

4. A second-order antisymmetry between quantum and macroscopic scales

4.1 Trans-linearity of the second kind and systemic phenomena

Trans-linearity of the second kind "should" represent the favorite field of the so-called "general systems theory". Indeed, when we are led to clarify that such trans-linearity can be expressed – among others options – by the "Hegelian" fusion of several functions $\Phi_{u\ i}$ in the form of an unique "synthesized" function $\Phi_{v\ m}$ where we can no longer recognize the original functions $\Phi_{u\ i}$, we immediately identify here a possible interpretation of the already mentioned (cf. section 3.3) founding postulate of general systems theory, namely "the whole transcends the 'sum' of the parts".
On the other hand, trans-linearity of the second kind, as we have seen it, has not any quantum attachment. Thus it may seem tempting to seek its origins among the systemic effects occurring essentially/irreducibly on the macroscopic scale. These systemic effects, we meet them every day. Just think of the *crowd effect* to which we will return later. The specific

investigation of these systemic effects by a general systems theory worthy of the name could perhaps open up new avenues for the reduction of the supra-quantum emergence problem. But, scientifically speaking, can we be sure that such a general systems theory does really exist? Or, more precisely, such a general systems theory, is it actually available in a form that can be directly used by current physics? Do we have a general systems theory where current physics appears as a particular case?
Establish the existence of systemic effects (see below), realize that the analytical approach specific to physics fails to capture all that is systemically essential, be aware that "the whole transcends the 'sum' of the parts," develop a *world vision* being consistent with the foregoing and so on, is one thing. Create a *strictly scientific approach* able to fill the epistemological void surrounding the systemic field is quite another one.

A text passage in Schrödinger's paper *Die gegenwärtige Situation in der Quantenmechanik* (Schrödinger 1935, p.826) – to the best of our knowledge, this passage is still rarely taken into consideration – suggests, despite its author and, of course, far ahead of time – *that the factors behind the extraordinary epistemic power of quantum physics are – except for one highly meaningful detail – the same hindering the emergence of a really operating general systems theory*.
The detail in question will be specified a little later.
Schrödinger, in order to highlight the problems which arise, according to him, from quantum superposition and complementarity, advances the following argument: When we have for each of two completely separated quantum systems S_1 and S_2 the maximum amounts of knowledge gathered in Ψ_1 and Ψ_2 respectively, then we have on this basis "Ψ_1 *and* Ψ_2" also a maximal knowledge about the two systems S_1 and S_2 viewed as the *overall purpose* of our interest. (*ibid.*) However, the inverse is not necessarily true: "The maximum knowledge of a global quantum system formed of several parts, does not necessarily give maximal knowledge up to each of its parts, even if these are entirely separate and without mutual influence." (ibid.)
This small passage closely resembles the systemic assumption "the maximum knowledge of a whole does not necessarily lead to the maximum knowledge of the all parts of which the whole in question is composed". However, this "close resemblance" is undermined by a particular antisymmetry, a "second-order" antisymmetry which is now beginning to take shape and which we will clarify more precisely in the following section (4.2): While at the quantum level, we encounter an antisymmetry between total knowledge and partial knowledge ("n maximum knowledges Ψ_u relating respectively n independent systems S_u can be grouped into a global knowledge $\Psi * = \Sigma \Psi u$, u = 1, ... n, *but the reverse is not true.*"), the main problem of systemic knowledge is absolutely symmetrical with respect to the relationship between the parts and the whole. In a specifically systemic context, the knowledge on a whole does not necessarily lead to a coherent understanding of the parts and , viewed from this angle, aligns the Schrödingerian inference. But *contrary to the Schrödingerian inference*, the approach of a macro-systemic phenomenon by proceeding in the opposite way symmetrically encounters the same problem: In this case the knowledge of all the (independent) parts, in contrast to the analogous quantum situation, does *not* permit to establish a coherent knowledge of the corresponding whole.
Let us illustrate this point by a previously mentioned systemic effect of choice, the crowd effect. Among 2000 people moving separately, "independently" each one of each other, most of them usually do not represent any significant danger. On the contrary a crowd gathering these persons is easy to be manipulated and may become really dangerous.
Experience shows that a crowd has intrinsic properties, not reducible to the individual properties of its members. However, in an absolutely symmetrical way, it is impossible to

infer from the overall characteristics of the crowd any knowledge on the individuals who compose it. And the violent behavior of a given person within a crowd does not allow us to know if the “same” person as an individual has a violent or nonviolent temperament.

4.2 Systemicity and macro-emergence

Therefore we call “'second-order' antisymmetry between the microscopic and macroscopic scales” the fact that the quantum antisymmetry of relations between partial and complete knowledge opposes the absolute symmetry of relations between complete and partial knowledge specifically characterizing the macro-systemic domain.
This second order antisymmetry is at the heart of the supra-quantum emergence problem.

The effort required to elucidate this supra-quantum emergence problem consequently passes through the following question: Since in spite of the difficulties outlined above, quantum physics has an intrinsically coherent mathematical formalism consistent with experience, why partly analogous / antisymmetrically analogous difficulties do complicate at the macroscopic scale the setting up of a scientifically relevant general systems theory endowed with universal formalisms allowing predictions suitable for experimental procedure?

From the quantum side perspective, the situation, certainly without lending itself to “intuition”, is clear on the formal level: Determining – in the words of the author (Schrödinger, 1935, p. 823 and passim) – a “catalog of predictions” about both superposed and additive states, the Schrödinger equation reinterpreted by Max Born simultaneously manages the interaction between the measurement process and the measured “object.” Here we find once again the key role of the Schrödinger-Born wave amplitude square $|c_n|^2$ setting for an observable A the probability $\wp(a_n)$ to take the possible value a_n when the system is in a given state. Indeed, this formalism – *via* interference term – is reconciling the fundamental linearity of quantum states as such and the “classical” non-linearity characterizing the knowledge we have of these states; a nonlinearity arising precisely from the interaction between the macroscopic experimental device and its microscopic experimentation “object”.
It seems quite widely accepted that the text including Schrödinger's “cat”, instead of highlighting the (alleged) absurdity of the quantum conception the author wants to attack, on the contrary has contributed to its consolidation.
Within a macro-systemic context, things look very different. Let us return to our example consisting of the crowd effect. It would be hazardous to assert that a person being individually affable but violent in a crowd “superposes” the both states “affable” and “violent”. In case we accept this kind of speculation, it would be difficult to establish the additivity of these states. Finally, any model going in this direction – but how? – might suffer from an absolute deficiency of predictability.
Formal mastering of macro-physical systems depends largely on the presence of linearity or at least of “classical” nonlinearity lending itself on sufficiently small intervals to infinitesimal significant linear approximations. However, as we have seen, specifically systemic phenomena fall within the trans-linearity of the second kind.
The development of a general systems theory powerful enough for mastering inherently systemic effects evolving over time – for example the ontogenic evolution of living beings from birth to death – thus passes by a formalization *stricto sensu* of this trans-linearity of the second kind as we had tried to sketch it – in an ultra-simplistic manner – through the expression (3-4).This formalization *should be supposed* to allow purely formal deductions

from its previous assertions; deductions interpretable as predictions entering an experimental procedure. Such a project is it possible? Could it have any chance of success? Given the requirement of absolute innovation, it seems rash to pronounce on that question. To get started, a formalization of trans-linearity of the second kind should “forget” all about linearity by which “classical” nonlinearity is negatively defined, while approaching linearity at the infinitesimal scale. And this would just be a beginning.
There are some research perspectives, but their presentation – even brief – would be beyond the scope of this paper. For the moment, the perspectives in question are reduced to inherently uncertain patterns of thought demanding a great effort in conceptualisation. A subsequent communication could be devoted to this point.

4.3 Quantum superposition v / s systemic horizon

Thus formal and experimental mastery of trans-linearity of the second kind is, in terms of macroscopic knowledge, a challenge of the highest order. As long as the trans-linearity of the second kind is not mastered, much knowledge – so-called knowledge (?) – dealing with macro-phenomena of everyday life includes vast *terrae incognitae*. It is said that quantum physics “escapes intuition.” This does not preclude quantum physics to generate scientific knowledge worthy of the name. At “our” scale, intuition seems “at home”, but in many cases and more specifically in all cases eluding linearity and “classic” nonlinearity, this intuition does not lead us to knowledge in a strict sense. In the field of trans-linearity, intuition certainly suggests that “the whole transcends the sum of the parties”, for example that the properties of individuals forming a crowd do not explain the overall properties of the crowd formed by these individuals and so on. But we can hardly compare this kind of intuitions to the epistemic power of “non-intuitive” quantum pyhysics.
In a context very far from ours, the Palo Alto school had established the *conceptual* distinction of “change 1” involving only variables and / or parameters of a given system continuing to “turn in the same way”, and “change 2” affecting the system as such. Since this approach has never been formalized, its impact on the philosophy of physics remains insignificant. A strict formalization of the “change 2” according to the Palo Alto school would represent a first step towards a minimal mastery of trans-linearity and supra-quantum emergence.

5. Conclusion

Meanwhile, a reinterpretation of Schrödinger's cat “according to E. Mayr” makes us conclude that the supra-quantum emergence problem – just like the second order antisymmetry encountered when moving from the quantum scale to the macroscopic scale – expresses for its part a superposition of two opposite antisymmetries: While at the quantum level, the fundamental linearity inherently tempered by the principle of superposition (Haroche, 2004, p. 26) leads – certainly at the expense of intuitivity – to an ultra-complex but formally mastered and globally consistent overdetermination free knowledge, the apparent intuitivity of the macroscopic scale – irreducible to its quantum “foundations” – is undermined by the trans-linearity of the second kind limiting physical knowledge *stricto sensu* to special cases characterized by linearity or, at most, by classical nonlinearity which a narrow horizon of overdetermination condemns to approximation.
Specifically, we find a highly significant antisymmetry between the two trans-linearities of the first and second kind we have attempted to identify through this paper. On the one hand, the trans-linearity of the first kind is characterizing the quantum knowledge which superposes strict linearities and thus transcends them, lending itself to a consistent formalization being

ultimately referred to the macroscopic world. “In their own way”, quantum physics escape the classical nonlinearity imposing on knowledge a narrow horizon. On the other hand, there is the specifically macroscopic trans-linearity of the second kind which also overcomes “in its own way” classical nonlinearity and its narrow restrictions. But while this trans-linearity of the second kind occurs indeed through all macroscopic phenomena passing to more and more complex / organized states, all the attempts to formalize it remain confined at a preliminary stage. And since the macroscopic emergence *problem* continues to be a *problem* as long as the elucidation of the transition from less organized macro-states to more organized states does not lead to formally mastered results, the formalization of trans-linearity of the second kind in order to constitute a consistent theory, adapted to predictive experimental approaches, belongs to the priority projects of the coming decades.

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