

# THE QUANTUM STRUCTURE OF KNOWLEDGE

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**Abstract :** This paper analyzes how conflicts of perspective are resolved in the field of the human sciences. Examples of such conflicts are the duality between the actor and spectator standpoints, or the duality of participancy between a form of social life and a socio-anthropological study of it. This type of duality look irreducible, because the conflicting positions express incompatible interests. Yet, the claim of “incommensurability” is excessive. There exists a level of mental activity at which dialogue and resolution are possible. Reaching this level only implies that one comes back to a state of undetermination between situations and interests, whose best model is a superposition of states in generalized quantum theory. Some applications of this strategy of going back below the point of “state reduction”, from the psychology of perception to the history of civilization, are presented.

**Keywords :** weak (or generalized) quantum theory, incommensurability, anthropology, phenomenology, quantum superposition, bistability, complementarity

Quantum mechanics looks paradoxical as long as one considers that it should describe (more or less completely) the world as it is independently of the activity of knowing. But paradoxes easily dissolve as soon as one accepts that this theory is essentially a formal expression of a certain class of situations of knowledge.

To understand this, one must first remember that the act of knowing usually consists in instituting a distance with respect to some fraction of what is the case, in order to anticipate and master this fraction (rather than merely adhering to it and partaking of it). For, “without separation there would have been no truth, but only *being*” Levinas (1990). One must then realize that this ideal program defines its own boundaries : it may hit insuperable obstacles in some domains, and it presupposes an initial pre-epistemic state in which the distance is not yet implemented. Quantum mechanics can be seen as a reaction of physics to the first type of boundary. It can be seen as a formal reaction to the limits of objectifying detachment of spatiotemporal phenomena, imposed by the finite value of the Planck constant. Its central strategy consists in setting up a second-order objectifying detachment, a substitutive objectification using a reflective strategy. Since the

spatiotemporal phenomena of microphysics cannot be disentangled from their experimental context, and since this entanglement hinders any possibility of picking out spatiotemporal objects endowed with a trajectory that manifests their permanence and identity, the only alternative consists in objectifying the very intertwining of phenomena and contexts. Quantum theories formally transcribe the modalities of such intertwining by way of their commutation relations of observables, and “uncertainty” relations, that both express the sensitivity of phenomena to the *order* of use of experimental modes of access. Indeed, no such sensitivity to *order* of access would exist if phenomena could be construed as independent of their *modes* of access.

Besides, the intertwining of phenomena and contexts prevents one from mastering the conditions of appearance of individual phenomena. It then prevents one from anticipating phenomena with certainty. As a consequence, quantum theory can only objectify an instrument of *probabilistic* prediction: the *state vector* in a Hilbert space. State vectors take the form of weighted linear *superpositions* of eigenvectors of a given observable, that express certain elementary symmetries of the corresponding *experimental situation*; and these symmetries, in turn, have quantitative consequences in terms of probabilistic valuation. As for global entangled state vectors, they express more complex experimental symmetries involving *several* observables (e.g. the three spatial coordinates), and they sometimes give rise to correlations between several variables. Conversely, “reducing” (or projecting) state vectors in order to take experimental information into account, introduces a symmetry breaking that restores the mutual independence of predictions bearing on these variables.

To sum up what has been said until now, the “uncertainty” relations, the symmetries of superposition or entanglement, and the symmetry breaking of state vectors, are *the objectified marks of the bounds of objectifying detachment in microphysics*.

This being granted, the quantum strategy of formalization provides those epistemic configurations where objectifying detachment is only partial or impossible with a remarkable model. Many such situations are concerned. The situations where, as in quantum physics, one hits upon insuperable limits of

decontextualization ; those where unaccomplished knowledge have not left enough time for integral objectification ; and also those which must impose to themselves incomplete objectification in order to take into account the participative and hermeneutical aspects of their domain. The latter configuration (knowledge extended to its empathic and interpretative dimension) is typical of human sciences (Geistwissenschaften), such as cognitive or phenomenological psychology, theory of rational decision, sociology of knowledge, or anthropology. The aim of weak (or generalized) quantum theory is precisely to formalize such a common epistemic configuration of incomplete objectification, by extracting it from the special features of microphysics (Atmanspacher et al., 2002 ; Zwirn, 2009 ; Danilov & Lambert-Mogiliansky, 2009 ; Bruza et al., 2009).

My aim in this paper is to show : (1) how and why the two central characteristics of weak quantum theories, to wit incompatibility of observables and entanglement, apply so well to certain fields of human sciences ; and (2) that realizing this provides us with new instruments of thought in the general philosophy of science.

I will start from a proto-quantum model of the phenomenology of perception proposed by Patrick Heelan (2004), yet adding to it some qualification and a step of generalization. This model involves the formal equivalent of (i) symmetry construction (represented by superpositions and entanglements in standard quantum mechanics), (ii) symmetry breaking (state reduction in quantum mechanics), and (iii) contextuality of phenomena (commutation relations in quantum theory). The relevance of this model is obvious for three modalities of perception at least : (a) construction of a stable object's *eidōs* beyond the variety of lived experience ; (b) perceptive bistability between two different eidetic forms ; and (c) perceptive bistability between an underinterpreted and an overinterpreted form of what can be considered retrospectively as the "same" perception. A fourth case will be added and discussed later on.

Let's start with case (a). Building an *eidōs* is tantamount to aiming beyond a manifold of individual features (things, aspects, or profiles) towards the *invariant* of which each individual feature can be considered as one contingent appearance. Thus, the *eidōs* of a material body is the pole of identity of the various

aspects it presents under many angles (Husserl 1970, §87). Accordingly, the essence of a class of objects is the ideal pole of identity or community, of which individual objects can be considered as mere instantiations. A central characteristic of Husserl's thesis is that we can have a true intuition of each essence, beyond the intuition of the variations that we synthesize in it; and that the intuition of an essence is exclusive of the intuition of a concrete individual that instantiates it. What is present in the intuition of an essence is only the manifold of *conceivable* individuals that could instantiate it (Husserl 1979, p. 417). The parallel between phenomenology and the epistemology of proto-quantum theories is easy to see. To begin with, aiming beyond particular individuals towards an *eidōs* is a process of symmetry construction, that operates at two levels.

At the first level, which is called antepredicative by Husserl, there is no sharp separation between the perceiving subject and the perceived object. The object and its determinations are not yet *constituted*, in the full sense that would be expressed in a categorial judgment. The protolinguistic act of perception involves nothing more than a vague assumption of identity of what is aimed at, and a tensed interest towards the hypothetical unfolding of its hidden faces. The assumed structure remains highly uncertain, so much so that when its expectations are disproved, it immediately loses its alleged transcendence, and immediately contracts on the immanence of what is present. At an even more primitive stage of perception, when no initial interpretation is proposed yet, or when any interpretative attempt is prevented by the extreme ambiguity of the sensorial stimulus, phenomenological analysis brings out an interpretative symmetry between several *eidōs*-objects.

As soon as a stable choice has been performed, as soon as perception is locked on a well-defined *eidōs*, a second level of symmetry construction occurs. In the case of a material body *eidōs*, the relevant symmetries are those of an Euclidean space: translations, rotations, and reflections. At this point, a comparison between the phenomenological *eidōs* and the quantum theoretical state vector can be developed. Quantum state vectors and *eidōs* are intersubjectively valid predictive forms. State vectors work as universal generators of probabilities by way of Born's rule. And Husserlian *eidōs* "(...) aim at creating,

beyond the present situation, a wealth of knowledge which be both communicable and usable *in the future*” (Husserl 1970, p. 74). An *eidōs* (superposition of profiles) and a state vector (superposition of eigenvectors) both consist in a combination and a weighting of various possible futures. True, there is one crucial feature of quantum state vectors that *looks* absent at first sight from the predictive structure of an *eidōs*: this is the wave-like *interference* of the various terms of a linear superposition. Indeed, simple geometrical profiles, in the sense of Desargues’s projective geometry would have no reason to interfere with one another. But in phenomenology, one does not deal with mere spatial projections. The so-called profiles of Husserl’s phenomenology are rather “adumbrations” (“*abschattungen*”), namely fuzzy-edged aspects surrounded by a “horizon” made of uncertainty and expectations. And these expectations anticipate other fuzzy-edged adumbrations. This being granted, no adumbration-connected expectation is independent of the expectations associated to further adumbrations. The mutual dependence of eidetic anticipations bear qualitative similarity with interference effects in quantum superpositions (Bitbol 1996).

Along with this interpretation of both state vectors and phenomenological *eidōs* in terms of anticipation, one can also offer an equivalent of Bohr’s complementarity and non-commutativity of observables; yet, without any value of something like Planck’s constant, one cannot derive “uncertainty” relations from there. Let’s remind that, in quantum mechanics, a case of complementarity and non-commutativity holds between (a) the observable whose eigenvectors appear in a superposition, and (b) another observable whose set of eigenvectors include the previous superposed state. In the same way, in the phenomenology of perception, there is a form of complementarity (in Bohr’s sense of mutual exclusivity and joint necessity) between (a) attention directed towards those individuals or particular aspects which instantiate an essence and are thereby “superposed” in it, and (b) attention directed towards the essence itself *qua* superposition.

After symmetry, one must examine symmetry breaking. In quantum theory, the latter is represented by state vector *reduction*. Reduction is the simplest method for revising a

prediction by taking into account the latest experimental result. In phenomenology, symmetry breaking occurs when one shifts from pure intuition of essence to one of its particular sensory fulfillment, thus giving rise to the perception of some *thing* given “in the flesh” (Husserl 1950, §88). Conversely, the formless flux of lived experience acquires the definite meaning of a profile of some *thing* only by way of its eidetic interpretation. In every case, in quantum theory and in phenomenology as well, symmetry breaking attests that concrete existence has burst into the contemplated idealization. Heelan writes that symmetry breaking is a step from thought to life.

But this transition also amounts to a cristallization of the object, and of the subject-object dichotomy that conditions it. Indeed, as long as one does not go beyond the intuition of an essence, or the representation of a state vector, there is a complete intermingling between (i) the subject who proposes (the essence or the state vector) according to the information available to her, and (ii) the object which has no other existence than a proposed or expected existence. But as soon as the intentional directedness shaped out by an *eidōs* (or the prediction shaped out by a state vector) meets an experiential (or experimental) fulfillment, the intermingling between the proponent subject and the manifest object breaks up. When the intention is fulfilled, or when the probabilistic structure has been redefined in order to take a measurement result into account, they can be reinterpreted through a judgment of existence : a certain object that matches the *eidōs* or is characterized by a certain value of an observable, has appeared. This accounts for the current denomination of state vector reduction as “objectification”.

The second phenomenon of perception that can be paralleled with the epistemological situation of quantum theories corresponds to the case where two (rather than one) *eidōs* are anticipated. Here, the symmetry construction does not operate within a single essence, but between two or many essences. A well-known example is given by the cases of bistable perception, especially the Necker cube drawn on a sheet of paper. Here, the complementarity concerns at least two couples of forms : either the two volumic interpretations, that are mutually exclusive in so far as they are based on two incompatible mental states, or both volumic interpretations on the one hand and the strictly surfacic

apprehension of the system of lines on the other hand. This situation has been successfully modeled in a weak quantum theoretical framework by Atmanspacher et al. (2004).

The third perceptive modality which corresponds to the epistemic situation of quantum theory, concerns another case of bistability : the bistability between an under-interpreted and over-interpreted form. The example commented by Heelan is that of a photography. But the case of stereograms (3D pictures hidden within an a colored surface (Levine & Priester 2008)) is even more illustrative. Under-interpretation consists in seeing the stereogram as a mere colored bidimensional surface. Over-interpretation consists in seeing through the latter, so to speak, the 3D picture. This difference between under-interpretation and over-interpretation can conveniently be understood in terms of detachment and commitment, or third-person versus first-person standpoints. Contemplating the scene in a detached way, in the third person, means seeing somebody in the process of staring at a rectangle of printed paper covered with colored spots. Apprehending the scene in a committed way, in the first person, means feeling fully concerned by what the picture is supposed to convey, and thereby perceiving what is represented in the figurative 3D space of that picture. Here again, the very first perceptive act can be construed as a phase of symmetry construction, a phase of indecision and superposition between two interpretative states. This superposition, as the former ones, expresses an intermingling between the putative subject and object ; the subject has not yet decided between the detached and committed stance, and the object, being correlative of each one of these stances, remains undetermined and suspended to an unaccomplished choice. The final perceptive step then involves an act of symmetry breaking that stabilizes the intentional directedness by focusing it either on the bidimensional entity “sheet of paper with colored patches” or on the three-dimensional picture the stereogram represents. It generates a subject-object dichotomy, since the subject has chosen her role (committed or detached) in the face of the object, and the object is the correlate of this choice. The structure of complementarity is easy to identify in this perceptive situation. It connects and opposes the 2D and 3D perceptions. The two types of perception are mutually exclusive, as already mentioned, due to the incompatibility of the

corresponding mental states. But they are jointly needed for a full characterization of the situation : the subject sees a 3D picture by means of the stereographic arrangement of the 2D spots of color. Be careful, at this point : the joint necessity does not cancel the mutual exclusivity. Indeed, one must never lose sight of the fact that saying “the subject sees a 3D picture by means of the stereographic arrangement on a 2D sheet of paper” is a loose way of speaking that merges two distinct modes of perception. This remark will have important consequences on our analysis of some misunderstandings typical of the sociology of knowledge.

This latter example of interpretative bistability has been developed by Heelan into a formal parallel with quantum theory. The parallel is convincing, but its significance must be qualified at this point. Indeed, the comparison could not even arise as long as one takes the quantum formalism for a description of pre-existing things in nature ; especially as long as one takes vectors in a Hilbert space for the description of their intrinsic states. After all, the states of the stereograms themselves (*An sich*) is by no means bistable, and therefore have no reason to manifest a *superposition* between the two poles of this bistability. But everything changes as soon as one realizes that the state vectors of quantum mechanics are purely predictive symbols, that afford the probability of results involving the whole measurement chain, from the preparation to the final configuration of the instrument. In both cases, the superposition concerns an anticipative capacity.

Let's come to the fourth perceptive modality, that was not mentioned in Heelan's paper. The reason why this additional modality looks interesting is that it fills in a lacuna in the list of structural analogies between phenomenology and quantum theory. Until now, we only considered perceptive determinations that are superposed due to the intermingling between the state of what is perceived and the state of the perceiving subject. But the most typical situation in quantum mechanics is such that not only the superposition, but also the *mutual entanglement of determinations*, arises from the intermingling between the measuring and the measured. One could say that the entanglement between the determinations of objects is underpinned by a kind of entanglement between those objects and the experimental modes of access. This is exactly what

occurs when one measures a global observable on a composite system, instead of measuring individual observables on each subsystem. In that case, what is known (i.e. what can be predicted with certainty) is nothing more than a mutual *relation* between individual determinations of subsystems, rather than these determinations themselves. One can thus know the distance between two particles without knowing their individual positions, or their global angular momentum without knowing their individual angular momentums. In addition, this global determination is *complementary*, and therefore exclusive, of local determinations.

One can easily find formal equivalents of this quantum epistemic configuration in the field of perception. Let's consider the Müller-Lyer "illusion" with arrow-like lines. When one *globally* perceives the couple of two lines with outwardly and inwardly pointing arrows, an apparent order relation is established between their lengths. The lengths of the arrows are mutually entangled, and this entanglement is explained by the fact that they are only *apparent*; that they are intermingled with the perceiving subject for whom they are appearances. Moreover, the *global* order relation between the two apparent lengths is clearly *complementary* of the *local* metric determination of each line, since their conditions of assessment are exclusive of one another. In the same way as, in the quantum case, the apprehension of a relation is exclusive of the apprehension of the mutually related determinations. The major difference with the quantum case is that the measurement of individual lengths can be considered as conflicting with the perceptive evaluation of their inequality (whereas the values taken by individual quantum observables do not cancel retrospectively the value of a global observable). This difference will be discussed in due time.

Let me now change the focus of the structural parallel between quantum theory and the human sciences. I will now deal with the problem of how a social consensus about scientific paradigms is obtained. The connection with the former reflections is not difficult to find if one remembers of the comparison made by Kuhn (1962) between perceptions (with their possible "gestalt-switch(es)"), and the process by which paradigms are adopted by large communities of researchers (Hoyningen-Huene 1993). The main interest of this parallel is not restricted to the fact of an

isomorphism that once more illustrates the generality of the quantum-theoretical scheme as a formalization of situations of intermingling between the knower and the known. This interest can be found, as we will see later on, in the aptitude of a weak quantum theoretical framework to indicate solutions in an apparently doomed debate about the status of scientific knowledge : does this knowledge give access to an atemporal truth, independent of the human community that elaborated it, or is it irretrievably expressive of an anthropological, cultural, or sociological situation ? When one's judgment is not blinded by some ideology, be it realist or constructivist, it is tempting to answer "both". Scientific knowledge tends towards an ideal of atemporality and universality ; and at the same time, this tension, the values that inspire it, and the decision of considering that a certain outcome is satisfactory, are rooted in some idiosyncratic individual and social ethos. This ethos belongs to living beings endowed with an intentional stance, to a civilization that tends to overrate the successes that can be obtained by imposing the convergence of intentional focusings (i.e. by setting up objectivity), and, of course, to a highly specialized community within this civilization.

How can one take these two apparently opposite views into account ? First of all by noticing that these views arise from two "complementary" standpoints. The standpoint of somebody who is fully committed in the quest for knowledge, and the standpoint of somebody who tries to detach herself from this quest in order to clarify its workings ; the standpoint of an actor and the standpoint of a spectator ; the first-person and the third-person standpoints. A researcher, being a committed actor of the quest of knowledge, tends to pass through the immanent surface of methods and to concentrate her attention on the allegedly transcendent object towards which the methods converge. Instead, an anthropologist, or a sociologist, wishing to stand as a spectator of the epistemic process of other scientists, tends to see the very belief in a transcendent object as a mere methodological instrument for an institutional and sociological endeavour. Realizing the duality of standpoints is however insufficient to resolve the controversy. Indeed, two options remain available at this point : absolutism and relativism. According to the absolutist option, the first-person plural standpoint of committed

researchers tend to give access to the world as it is in itself and thereby to reach truth. Here, the actor reveals a transcendent realm, and the anthropological spectator only reveals the way an actor gains access to such transcendence (or the way an actor can be misled). According to the relativist option, instead, each one of these two standpoints reaches a form of truth about the nature of knowledge, even though such *relative* truth remains inaccessible to the other standpoint. The truth of the actor is that her own social, cultural, biological situation is nothing more than a provisional curtain that separates her from *reality*, yet simultaneously offers tools for pulling the curtain away. The truth of the spectator is that the very word “reality”, which is so often uttered by the actor, only refers to the provisional term of a process of stabilization of beliefs that can by no means be made independent from the biological abilities, technological resources, and social practices that are involved in the process of research.

But do we have only these two options : unifying the field of truth by absolutizing the standpoint of the actors of research, or accepting to fragment the field of truth into many incommensurable epistemic standpoints, including the standpoint of the anthropologist or sociologist of science ? Actually, there is a third option. This middle way allows one to unify the two standpoints on knowledge, committed and detached, first- and third-personal, while preserving their diversity, their local validity, and their mutual exclusiveness. This sounds like a utopia. But in fact, such a middle way is already familiar to us. Let’s think again of the perceptive bistability between the 2D surface of a picture and the 3D stereogram. Unifying the two mutually exclusive perceptive states is allowed in that case by a construction of symmetry between them ; namely by acknowledging that these perceptive states are potentially realized by a single subject who has not yet restricted her own interpretation, and has not yet posited a determined object (colored surface or 3D configuration). It is only during the step of symmetry breaking (when a decision to see the surface or the 3D configuration is taken) that the two perceptive states manifest their being mutually exclusive. Moreover, the perceiving subject can also decide to withdraw from the state of separation between her and the perceived object, from the state in which a

determined configuration is perceived, and to recover the symmetric and superposed state in which her perceptive configuration is undetermined. A similar analysis can be applied about the conflict of two archetypal epistemic positions in the sociology of science. Besides the obvious choice between imposing unity under one such position (the first-person authoritative position of committed researchers), or accepting their relativist fragmentation, there is a middle way : reunifying these positions in the state of indecision and indiscrimination adopted by a subject capable of adopting any one of them. The potentialities of this kind of “suspended” subject are larger than those of any one of the two options taken in isolation. But isn’t such a “suspended” subject a theoretical myth ? By no means : it corresponds to the position of a mere “citizen” who does not have to endorse the professional interests of one of the two circles (researchers in the sciences of nature, and sociologists / anthropologists of science).

The reason why the controversy goes on, is that the protagonists overrate one of the two available epistemic perspective and ignore their own aptitude of adopting the other one. Researchers in the sciences of nature overrate their intentional projection towards an object, by declaring that this should (in the long term) give them access to some absolute and unique truth ; and anthropologists of science overrate their clinical inventory of the socio-cognitive acts that generates a belief (say in the existence of a certain object-entity) by declaring that this inventory is enough to destroy the realist claim of researchers.

But we must realize where *we* are and what *we* are doing at this precise moment. The reason why the controversy can be formulated and developed at all (especially by us, now) is that both contenders share a common language which is neither the language of one, nor the language of the other, nor a language completely foreign to both, but a language appropriate to a symmetric state of indetermination, of suspension of any commitment into one perspective, and to entering into any one of them. Here again, this language is that of a state of plain “citizenship”, of an ability to discuss in the common Agora (Stengers 2006).

At this point, we must insist on the fact that Heelan’s proto-quantum analysis of bi-stable perception, that we have just

extrapolated to the case of a duality of epistemological perspectives, has at least one non-trivial result in store. This result is the strict non-commutativity of the projections operators in a state of perceptive detachment and in a state of perceptive commitment, respectively. The colored 2D surface of the picture can be considered as a mediator towards the 3D object ; but a 3D object does not refer automatically to any 2D surface. Similarly, the network of cognitive operations and social interactions can be considered (by realists) as a hopefully transparent mediator towards the object of scientific representation ; but the represented object does not refer automatically to the the field of immanent operations that precondition its constitution. In epistemological terms, this lack of indifference to the order of perspectival projections can be expressed thus : (1) The detached / reflective standpoint of and anthropologist of knowledge or of an empirist / transcendental epistemologist is more open, and more flexible than that of a scientific researcher, because the field of immanence on which they concentrate their attention potentially contains in it several transcendent pictures of the world ; (2) Conversely, the committed standpoint of a scientific researcher who believes in the transcendent entities whose intrinsic properties she is allegedly trying to disclose turns out to be more motivating, and more immediately operational as long as there are no serious doubts about the reigning paradigm. One can thus understand a widespread preference for the reflective standpoint of a large fraction of philosophical thought, except in the case the topic of the philosophical research is precisely to understand the perspective of scientific research. One can also understand the widespread preference of the scientific community for “spontaneous realism”, except in the historical situations when paradigmatic consensus is threatened and the necessity of coming back to the immanent (empirical, instrumental, axiological) material that previously underpinned unquestioned transcendent representations starts to be felt acutely. In both cases, there is an exception to the spontaneous preference connected to a given standpoint. The fact that there is such an exception suggests that full adoption of such standpoints is not realized, and that both of them develop on the background of a symmetrical and undetermined position that is ready to reemerge whenever narrow-minded work along with a given

standpoint fails. A philosopher or an anthropologist can easily become receptive to the researcher's standpoint in order to understand what she takes as a "naive" picture of the world (especially when she wants to build an evolutive philosophy, a philosophy working as a "travelling companion" of the history of science). In the same way, researchers living in a "revolutionary" period of their discipline fall prey to doubt, and they cannot overcome it without provisionally adopting the standpoint of a reflective philosopher (Einstein's 1905 and Heisenberg's 1925 mixture of kantianism and instrumentalism illustrate this move). Once again, the true location in which these mutually exclusive and jointly necessary epistemic perspectives can be unified is a symmetric and superposed epistemic state from which both are accessible.

I would now like to provide an instance of the type of endless controversy which is generated by our difficulty in identifying a middle way between epistemological absolutism and relativism, and its possible resolution in a quantum-like conceptual framework. This instance focuses on the provocative claims of the anthropologist of science Bruno Latour (1997, 2001). Bruno Latour denies that Ramses II, the well-known Egyptian Pharaoh, died of an infection by *Mycobacterium Tuberculosis*, despite the bone anomalies that testify this disease. The reasons he gives for this denial is that in that ancient time, no scientific work had yet characterized *bacteria*. Of course, many scientists and philosophers of science have indignantly rejected this argument wondering how Latour could ignore the plain fact that bacteria *exist* independently of our science. However, if we think harder about it, we soon realize that Latour's argument is not flatly wrong but rather displaced. Latour's denial develops as if he could just ignore *his own* historical situation and epistemic perspective. To understand this, we must first adopt a neutral attitude about scientific realism (thus tacitly going along the above-mentioned epistemological middle way). We must first remind how the beliefs associated to scientific theories crystallize, without holding any (negative or positive) metaphysical prejudice about these beliefs. Let's notice in this spirit that, before being a description of anything, a scientific theory is a corpus of prescriptions. It prescribes to *see* a certain class of phenomena *as* manifestations of the properties of certain objects.

It then prescribes to predict and to act according to the order of its mathematical formalism or its taxonomy, and it rewards believers by success in their actions. When this kind of prescription is formulated, no limit in time is added. A scientific theory does not prescribe to predict and act under the presupposition that its objects have acquired causal power at the moment *of its own creation*, but under the presupposition that its objects have *always* had this causal power and will retain it *for ever*. The success of scientific activities crucially depends on this edict of perennality. Indeed, even when they are not archeological, scientific researches need to extrapolate the causal power of their postulated objects in the past. Just think of what astrophysicists would do if they could not retrospectively consider that the photons that penetrate in their telescopes were already endowed of causal power before 1905.

Now, as soon as many successful actions are performed under the presupposition of the perennity of a class of theoretical entities, these entities acquire a strong ontological status. The clauses of “always-already” and “for ever”, combined to the success of the practices they underpin, strengthen the belief in the permanent and intrinsic existence of these entities, for every human being who partakes of the scientist’s form of life, and for many human beings who partake of our scientific-based culture.

This being granted, how can someone like Bruno Latour, whose historical situation is later than Pasteur’s and Einstein’s scientific paradigms, deny the conceptions of time that underpin them? What gives him the right to reject their clause of perennity, without which the success of their sciences would be severely restricted? This would be admissible only if he could show that *his* conception of time, according to which objects do not have causal powers before their historical constitution, does not conflict with *theirs*. This would be easy for him if he accepted that his view of time is relevant only in the framework of the practice of an anthropologist of laboratories. After all, no anthropologist of science can ignore that the objects and properties postulated by researchers change quite radically across the history of science, even when this change is veiled by the persistence of words. No anthropologist can overlook the fact that each object newly characterized by scientific researchers is endowed by them with a claim of ahistorical existence. In other

terms, the time of anthropologists does not deny the time (or the successive times) of laboratory researchers, but rather takes it as a second-order object of study. If anthropologist Latour contented himself with acknowledging this point, the scope of his propositions would be narrower, because he would explicitly be bound to his own class of standpoints. But these propositions would not contradict those of the studied scientific community either, because they would overly have another domain of validity. Latour would then recover credibility at the rate his claims would lose dramatic force. But this is a weak method for avoiding conflicting positions, a method typical of relativism that is implicitly rejected by Latour.

Latour rather insists on the validity of his own anthropological descriptions. He points out that our description of knowledge as an interaction between subject and object by way of instruments comes after a difficult operation of sorting out in the field of phenomena, individual actions, and collective negotiations. Such a description can then only be a rational *a posteriori* reconstruction, and is thus devoid of any *a priori* truth; it can claim no priority with respect to any other conception of the status of past events. This is the reason why Latour so insistently suggests that the power of natural causes such as microorganisms *really* (and not only relatively) starts when their “purification” has been achieved by a research project. The problem is that, by making this claim, he falls prey to the same deficiency as the one he blames scientific researchers for accepting. Indeed, he overrates and absolutizes an evaluation that is typical of his own epistemic situation. After having rejected the relativist solution of the conflict of perspectives, he comes surprisingly close to endorsing its (despised) opposite, namely the absolutist solution of the hegemony of one (anthropological) perspective over any other. No wonder the supporters of the other hegemonic solution (the hegemony of natural sciences) are so sturdy in their reaction.

The best way of resolving the conflict between the perspectives of anthropological detachment and scientific commitment first requires complete renunciation to both absolutisms, thus accepting that none of the two (cosmological and historical) conceptions of time can claim exclusive truth for itself. Resolution of the conflict then demands that one retains the general principle of a relativist defusing of the debate, yet

avoiding to crystallize it within a double-truth thesis and to perpetuate it by declaring that the two perspectives and the two truths are incommunicable. Instead of petrifying the mutual exclusivity of perspectives by associating them local truths, it should be realized that the very fact one is able to characterize them as “perspectives” presupposes a logically prior standpoint, from which they can also appear as jointly indispensable and therefore “complementary”. This latter standpoint involves a symmetrical state of superposition, or bistability between the two epistemological options ; it belongs once again to the “citizen” who lies behind the social roles of an anthropologist and a research scientist. The “citizen”, with her superposed epistemic state, has no reluctance to see both *times* (the time of history and the time of rational reconstruction) coexist, since both of them are constitutive of her civilizational ethos. She has no difficulty either in making a choice (thus breaking the symmetry) whenever the necessity of adopting a certain mode of action or a certain internal logic of discourse can no longer be ignored.

To conclude, I’ll present an equivalent of the fourth perceptive modality in the history and sociology of scientific knowledge. In this fourth perceptive modality, the entanglement of object’s determinations is underpinned by the intermingling between these determinations and a *global* experimental mode of access. Accordingly, the mutual entanglement of determinations is destroyed only when one makes use of several *local* instruments of access. In psycho-physiology, the example I developed was that of the Müller-Lyer arrows. These arrows are perceptively connected by the global relation “longer than”, but cannot be ascribed an individual length before local measurements have been performed with a ruler (Bitbol, 2010). Measuring individual lengths could either confirm or disprove the global perceptive assessment of a metrical relation. This example illustrates the complementarity of local and global determinations. It also illustrates the difference between a type of assessment of length which depends on marginal elements of context such as the orientation of arrows (the gestalt-perception procedure), and another type of assessment which is independent of such context (the ruler procedure). The second type of assessment, with a ruler applied locally, is tantamount to a procedure of constitution of objectivity in the most general sense, since while one still pay

tribute to the relativity of determinations to a mode of access, one makes them as independent as possible of any marginal circumstance concerning the time, location, subject, and environment of the measurement.

One can also consider other illustrations of the same perceptive modality, in which the complementarity of determinations is historical rather than synchronic, and in which constitution of objectivity is explicitly required as a condition to be freed of contingent circumstances, rather than something that is implicitly supposed. Let's consider the case of temperature assessment (Chang, 2007 ; Peschard & Bitbol, 2008). For thousands of years, the only way to assess temperature consisted in perceiving the difference of heat sensations obtained by touching several bodies. The only (approximately) accessible quantity was the relation between two heat sensations, since the intermingling between the determinations and the state of their psycho-physiological mode of access was complete. Even worse, relational declarations such as "A is hotter than B" were strongly dependent of contingent physiological circumstances. They could have to be revised according to whether one had touched a very hot or very cold body just before the assessment was done. This gave rise to an urgent need for an "objective" assessment of thermic states, namely of a progressive detachment of thermic states with respect to the contingent features of their modes of access. Detachment does not mean, once again, complete independence with respect to any technique of access, but only stability across a multiplicity of techniques and circumstances. The quest for an objective and precise thermometric assessment therefore coincided with the patient establishment of congruence and covariance of the linear domains of thermic dilatation of various materials (alcohol, metals, mercury etc.). But in order to be trusted, these thermometric indications had to be found in reasonable agreement with thermic sensations in standard contexts. This explains a widespread confusion between the explanation of measured thermic variables and the explanation of "heat" as sense datum. In many articles and books of philosophy of mind, it is often claimed that belief in the ineffability of sense qualia is refuted analogically by the fact "heat" was reduced to average molecular kinetic energy. In this widespread argument, the double status of heat, as felt and measured, is implicitly but

incorrectly exploited. Indeed, as far as one pushes the explanation of the objective correlates of heat, its relevance is bound to stop (as Von Neumann pointed out in his *Mathematical foundations of quantum mechanics*) at the point where something is felt and *lived*. Thermodynamic or kinetic explanations cannot account for the very circumstance that there is something it is like to feel heat. They can account for the detached fact of the relation between two sensations of heat, but not for the participative fact of the felt quality of heat. The reductionist argument thus seems to ignore a form of complementarity between (i) the intermingling of the feeling and the felt in sensation, and (ii) the objectifying detachment required by the measurement of temperature and other thermodynamic variables. One tries incorrectly to put everything on the same plane, by calling both temperature and heat sensation “natural phenomena” because one does not fully realize that aiming at a value of objective temperature and immersing oneself in felt presence come under two mutually exclusive stances. These two stances are well described by Goldstein (1983, p. 426). “One usually makes a distinction between two possible attitudes towards nature : either knowing it or acting on it. But this dichotomy is not sufficient. One should rather speak of an attitude of immediate acceptance and an analytic attitude”. Here, knowledge is equated with receptivity, with the acceptance of the noetic flux which includes sensations ; and action is equated with the analytic attitude, namely with the discrimination between factors and circumstances which enable progressive extraction of invariance and then objectivity. In the attitude of immediate acceptance, the intermingling of the knowing and the known is complete : “As long as our attitude remains purely receptive, there is no clear-cut division between living and non-living nature”. Conversely, the analytical attitude yields a structured representation of “part of (the events) that represent the totality of the world ; they are so to speak outlined against this world”. It is at this point that dissolution of the intermingling takes place ; a fragmentation and a detachment of the objectified part of the world then occurs. The two attitudes are clearly exclusive of each other : receiving or intervening, accepting or discriminating, maintaining the intermingling or extracting an objectified domain. But does this entail a strict duality of the modes of

knowledge, and a relativity of its contents to each one of these modes ? The answer to this question is once again negative, for a reason which is becoming familiar to us. Below the level of the duality of attitudes, we find the very source of attitudes, the indiscriminated state that corresponds not only to a superposition but to an absence of any preliminary decomposition according to the eigendirections of some observable : “This standpoint does not only pertain to the unscientific human being of even to the primitive human being. In a scientist, it can coexist with the standpoint of scientific analysis”. A researcher is also a human being receptive to any possible attitude ; before having adopted one or the other of the two basic attitudes, she is in the underlying basis of attitudes, in “openness”, in multi-valued disposition. This is the most general cognitive equivalent of quantum superposition and entanglement.

One can easily summarize this article by quoting a cryptical remark Bohr uttered during a conversation with Åge Petersen : “There is no quantum world. There is only an abstract quantum description” (Petersen 1963). Quantum theory is not a theory of objects in a micro-world ; it is the abstract formalization of a universal type of description applying to any situation of knowledge in which one must take into account the limits of objectifying detachment. This greatly increases the confidence one can have in the perennity and scope of the quantum model of theorizing.

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