PERSPECTIVAL REALISM AND QUANTUM MECHANICS

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ABSTRACT

A complete reappraisal of the philosophical meaning of Everett's interpretation of quantum mechanics is carried out, by analysing carefully the role of the concept of "observer" in physics. It is shown that Everett's interpretation is the limiting case of a series of conceptions of the measurement problem which leave less and less of the observer out of the quantum description of the measuring interaction. This limiting case, however, should not be considered as one wherein nothing is left outside the description. Something is still needed besides this description: pure cognitive capacity, the subject, or, in a very abstract sense: "mind". The set of branches which arise, according to Everett, from a measuring interaction, gain a renewed signification. They do not refer to distinct "worlds", but to the points of view "mind" can identify itself to. This idea is compared and contrasted with Squires' "selection" of a branch by the mind (without quotation marks). Finally, the notion of indeterminism in quantum mechanics gains an unexpected and new light from a strict application of the previous ideas.

1. Perspectival reality

The central idea of perspectival realism is the following: a "real object" is but the class of all its aspects, seen from different points of view. Some refinements must be added to this definition, if one is to reach a consistent conception of reality. First of all, one must avoid any reference to the object when dealing with the "aspects" which are its constitutive building blocks. Saying that an object is defined by the class of "its" aspects, i.e. by the class of aspects *of this object* obviously departs from the previous rule. To prevent circularity, one should rather use an internal criterion allowing one to link up the "aspects" in a single bundle called "the object". The said internal criterion can be, for instance, the existence of a transformation T (usually considered as smooth, continuous and reversible) which allows one to infer any "aspect" of the bundle from the knowledge of some other aspects. Secondly, to be general, the definition of the "real objects" must go beyond spatial metaphors. The "aspects" constituting a real objects should include experimental results. The concept of point of view should accordingly

be extended so as to encompass that of preparation of a measurement, and/or that of the particular context on the background of which an instrument reading becomes an experimental result. Thirdly, we cannot limit the definition of a "real object" to a set of *actual* aspects, lest we are content with a flat version of Machian positivism. We must then supplement the actual aspects with all the (visual, auditive, tactile, or experimental) *possible* aspects which can also be inferred from actual aspects by using the transformation T.

As it stand, this definition of real objects was developed by several thinkers during our century. Let me first recall Russell:

"The 'thing' of common sense may in fact be identified with the whole class of its appearances, where, however, we must include among appearences not only those which are actual sense-data, but also (other) sensibilia(...)"[1] Russell here insists on the third of the above condition, since "sensibilia" refers both to actual and potential sense-data: "I shall give the name sensibilia to those objects which have the same metaphysical and physical status as sense-data, without necessarily being data to any mind."

Schrödinger agreed with Russell about the necessity of supplementing actual appearances by potential ones in the definition of "real objects". He also stressed the second condition: supplementing the spatial points of view by the *experimental* ones.

"(a material object) is composed, not only of my own sensations of it, but also of the imagined sensations I would have in turning it round, looking at it from different angles; in addition, it is composed of the perceptions I imagine you to have of it, and also, if you think of it purely scientifically, of all you could verify and would actually find, if you took it and dissected it to convince yourself of its intrinsic nature and composition, and so on. There is no end to enumerating all the potential percepts and sensations (...) that are included in my speaking of its (object) as of an objective feature of the 'real world around us' "[2].

More recently, P. Heelan reformulated, within a phenomenological framework of thought, the basic idea of perspectival realism:

"A profile of a particular object is a particular manifestation of that object in and through perceptions (...). Systematically associated with any profile is a manifold of different possible profiles of the object which exhibit all the various facets that the object can manifest under a certain system of variations."[3]

It is interesting to notice that, in Heelan's formulation, the first of the above three conditions is stressed, under the name of "essence" which replaces that of

1. B. Russell, *The relations of sense-data to physics* (1914), in: *The collected papers of B. Russell*, (G. Allen and Unwin, London, 1986) Vol. 8.
2. E. Schrödinger, *Nature and the greeks*, (Cambridge University Press, Cambridge, 1954).
3. P. Heelan, *Space perception and the philosophy of science*, (University of California Press, Berkeley, 1983). See also M. Merleau-Ponty, *Phénoménologie de la perception*, (Gallimard, Paris, 1945)

"transformation". "An essence is the generative law of a system of profiles", or "The essence of the object is the set of invariant structures that generates the manifold of its profiles."

The metaphysical originality of perspectival realism appears to be that this doctrine is just as little ontologically committed as positivism, while it retains an epistemological version of transcendence. Let me develop this apparent contradiction.

To begin with, fulfilling the first above condition allows one to *state* the rules of construction of a "real object" using pre-objective building blocks, rather than merely *pointing* at the object. Such a construction removes from the object the kind of ontological primacy and opacity involved by purely ostensive definitions. Moreover, it leaves no ground for the concept of an "external" world. Provided one accepts that objects are but bundles of either percepts or Bohr's "phenomena", it is indeed absurd to contend that a percept (or phenomenon) is "caused" by an object. This implies that, conversely, inferring the existence of some "external" object from a given actual percept or phenomenon is not a valid move.

Russell claimed in 1914 that abandoning this kind of inference should be construed as a philosophical ideal:

"Wherever possible, logical constructions are to be substituted for inferred entities."[1]

Now, despite its radical lack of ontological committment, perspectival realism leaves enough room for a minimal, purely epistemological, variety of transcendence. Indeed, a bundle of "sensibilia" goes clearly beyond any set of *actual* percepts, in so far as it both relies on a generative transformation, and includes all the potential percepts which are mutually connected through this transformation. This epistemological transcendence may explain the common illusion of ontological transcendence:

"Since the thing cannot without indefensible partiality be identified with any single one of its appearances, it comes to be thought of as something distinct from all of them and underlying them."[1]

The questions on which I wish to focus my attention at this stage, are the following: can the perspectival definition of reality be applied at the quantum level? In particular, what is the status of *potential* percepts in this case?[4].

2. Context and beyond

The answer to the first of the previous questions must apparently be negative. The notion of result of a potential experiment, stated by means of a counterfactual proposition, cannot be extended to the case of atomic or subatomic objects without generating, in many cases, a contradiction with quantum predictions. For instance, it suffices to assume both a certain version of locality condition, and the hypothesis of counterfactual definiteness, to derive Bell's inequalities[5].

4. E. Schrödinger, *Science, theory and man*, (Dover, New York, 1957).
5. B. d'Espagnat, *Phys. rep*. 110 (1982) 201.

The features which underly this incompatibility between the predictions of quantum mechanics and a systematic use of the concept of potential experiments are well-known. First of all, once an observable has been measured on a microscopic object, the result of subsequent measurements of other observables depend on the result of the first measurement. This renders irreversible the transformation T which associates the "aspect" of a given bundle to one another. Secondly, the measuring apparatuses of non-commuting observables A and B are mutually exclusive. Any conjunction of statements bearing on the outcomes of measurements of two non-commuting observables is thus operationally meaningless, even if one of these statements is counterfactual. This idea can be restated as follows[6]: each context (in this case each incompatible experimental arrangement) gives rise to a particular event-language, in which the results of measurements of any set of commuting observables can be expressed. A conjunction (or disjunction) of (actual or counterfactual) statements bearing on non-commuting observables merely lacks the one event-language in which it is meaningful. Now, the structure, at a meta-linguistic level, of the set of these event-languages have been shown to be that of an orthocomplemented modular lattice[7]. It is thus isomorphic to Birkhoff's and Von Neumann quantum logic[8].

This, and other related results[9] constitute the basis for a certain class of perspectival interpretations of quantum mechanics[10]. According to these interpretations, any experimental statement is relative to a certain Boolean sublattice, considered as a frame of observation.

We must examine at this point what sounds like a verbal paradox. Quantum mechanics fits quite well with some sort of perspectival interpretation, whereas the same theory seems reluctant to be comprehended within the framework of perspectival realism.

In fact, this "paradox" only brings out in an illustrative manner what we are already aware of, namely that for perspectival realism to be possible, it is not enough to define perspectives. Another condition is crucial: the perspectives on which the definition of the objects is based should not be strictly exclusive of one another. In perspectival realism, the concept of an object arises from the idea of a kind of universal context wherein each point of view is adopted by an (actual or potential) observer and wherein the whole set of significant dynamical variables is (potentially or actually) measured. The perspectival definition of an object as a conjunction of counterfactual experimental statements involving a large (or even infinite) number of possible contexts is then transformed into a conjunction of counterfactual statements involving a *single* context: the conjunction of every possible context.

6. P. Heelan, *Synthese*, 21 (1970) 2.
7. P. Heelan, *Found. Phys.* 1 (1970) 95.
8. G. Birkhoff and J. Von Neumann, *Ann. Math.* 37 (1936) 823.
9. M. Davis, *Int. J. theor. Phys.* 16 (1977) 867.
10. R. Healey, *Noûs*, 18 (1984) 591.

Now, the very possibility of the latter conjunction amounts to saying that every experimental proposition can be expressed within a single event-language or, equivalently, within a single Boolean frame. It has indeed been demonstrated by Watanabe[11] that a set of experimental propositions, stating both a context (or experimental procedure) and the associated result, has the structure of a Boolean lattice *if the context is unique*. On the other hand, when several contexts are involved, the (complemented) lattice of the experimental propositions is in general not Boolean. This lattice becomes Boolean in a particular case: when it is possible to define a product (or conjunction) of contexts. The field of applicability of perspectival realism as we stated it previously thus corresponds to the conditions which transform the set of the experimental propositions into a Boolean lattice. This correspondance seems to be but another way of asserting the incompatibility between perspectival realism and quantum mechanics as they stand.

However, if the said correspondance is granted, the study of lattices of experimental propositions can become a powerful tool allowing one to determine what one should modify in both perspectival realism and (the interpretation of) quantum mechanics, if they are to be rendered compatible. Taking the step from a mere perspectival interpretation of quantum mechanics to a true perspectival realist reading is not impossible with some fitting-up work.

To start with, let me sum up the conditions of possibility of perspectival realism, which are tantamount to the conditions of possibility of a boolean structure of the set of experimental propositions. A set of experimental propositions has the structure of a Boolean lattice provided one of the three following conditions is fulfilled:

1. The propositions involve no context at all.

(Indeed, in this case, the logical operations between the propositions are the set-theoretic operations among subsets of results)

2. The propositions involve a single context.

(When the context of experimental propositions is unique, the conjunction or disjunction of experimental propositions can be reduced, as in the previous case, to the corresponding set theoretic operations among subsets of results.[11])

3. There are several contexts, but it is possible to define a conjunction of these contexts.

(The set of contexts here reduces to a single composite context, and one is thus brought back to the second situation.)

The third condition is obviously incompatible with experiments at the atomic or subatomic level, but what about the first and the second?

In so far as the traditional cut between the object and the experimental device is maintained, each of the (possibly incompatible) experimental devices represents a well-definite context. In this case, no possibility is left to perform a shift from a many-context language to the one-context or the no-context language which are required by conditions 1. or 2. But as it is well known, this cut (which is almost exactly identical to

11. S. Watanabe, *Suppl. Prog. Theor. Phys.*, 37-38 (1966) 350.

Von Neumann's cut) has no reason to be frozen at a definite position in the description of any quantum measurement. It is thus conceivable that part or the totality of what we call in the traditional view "the context" be encompassed by an overall object or objective process. This displacement of the boundaries between "the context" and the "object" could lead to fulfillment of conditions 1. or 2.

Let us take as an instance the most extreme position of this boundary. This extreme position is such that every *thing* is described as an object of the theory, whereas no *thing* remains outside its domain of description to play the role of the context. Thus, condition 1 is fulfilled. Now, this corresponds quite closely to Everett's view of quantum mechanics. Everett indeed suggested that the status of 'real object' in quantum mechanics must be ascribed to the multidimensional wave describing not only the set of those particles which are submitted to a measurement, but also those which belong to the whole apparatus and to the observer's body.

Such a conception of the object as being every *thing* which partakes in the measurement process (or even every *thing* in the universe) however raises considerable problems as soon as one tries to apply to it the general perspectival construction of everyday-life and classical real objects. How could we transpose, to begin with, the idea that an object is made of all the possible sensations I would have "looking at it from different angles"? This expression amounts to supposing that the "observer" (myself), being completely independent from the observed object, he/she can change his/her point of view on the object at will. But Everett's 'real object' includes the observer's body. Even what we would call classically "the (experimental or spatial) point of view from which an observer looks at an object (i.e. at the object in the restricted sense)", is encompassed within the definition of the overall 'real object'. Similarly, how could we understand, in Everett's frame, that an object is also made of all the results of possible experiments, of "all you could verify and would actually find" on it? Indeed, the whole experimental set-up is part of the object itself, and choosing a new experiment would amount to change the object.

These difficulties clearly arise because the construction of real objects, which we are now trying to transpose to Everett's interpretation of quantum mechanics, relies heavily on a common-sense conception of the observer. In this conception, the observer is implicitly a "person" with a spatial position and bodily features, and the very definition of the possible situations whose combination gives rise to a 'real' entity depends in a crucial way on this assumption. The observer has to *move* around the object to see it from different places, or he has to *change* its experimental set up without changing the object itself.

There is a way to sort out the difficulty. To summarize, it amounts to saying that, in Everett's interpretation, every *thing* is within the field of quantum description, but not *everything*. There is *something* which remains definitely outside this description, in so far as it remains outside any description of the objective world. This *something* is the Mind in a very abstract sense: the pure knowing subject (Mind or subject in this sense is no "substance", but only a logical correlate of experience: that for which there is experience). As Schrödinger would say, to explain the absence of Mind in the objective

world: "Mind is eminently subject, and it thus eludes any objective analysis."[12]. Our task is now to substitute this abstract Mind to the human observer, in the perspectival construction of a real object.

Carrying out this substitution analogically, we would fancy that the complex 'real' system (object in the restricted sense+apparatus +observer's body) is the set of all the aspects of it the mind would perceive by "turning it round, moving it, looking at it from all different angles". This seems absurd. If mind is placeless, how could it change its *point* of view? If it has no eyes, how could it look at all?

But Everett's formalism offers a very straightforward generalization of the concept of point of view. Once the wave function of the overall 'real system' has been defined (and provided it automatically selects its own 'preferred basis', which is a problem in its own right that I shall not discuss here), this wave function displays, at any given time, the set of memory states which result from the interaction between the object in the restricted sense, and the observer's brain. Rather than saying that this interaction results in a branching off of the world in many worlds, I shall rather consider that it discloses available *aspects* of the one world and confronts Mind with all its own *possible statesof experience* in a given situation. Take then the concept of "point of view" in its most figurative sense, the one you use when you notice, for instance, that your point of view on life is determined by your past experiences. This kind of "point of view" represents in some way no less than your personal identity. Now, in this figurative sense, the set of memory contents displayed in Everett's state vector of the 'real system' under consideration is identical with the set of all the 'points of view' Mind can possibly have on the system. Reciprocally, the 'real system' can be defined as the set of (figurative) points of view Mind can possibly have on it, in good (formal) agreement with the perspectival conception of reality.

3. One mind, many points of view.

The idea that Everett's formalism can be interpreted as a technique for displaying the whole set of figurative points of view on a 'real system' Mind can adopt, is not devoid of difficulty.

It is at least clear that these difficulties are definitely distinct from those faced by the many-worlds conception of the same formalism. Whereas the many-worlds interpretation sounds like an imaginative fantasy whose challenge is to justify the necessity of generating many inobservable situations, the possible-points-of-view interpretation threatens our most intimately rooted beliefs concerning personal identity, and its relations to space and time. These are the problems I must now address.

To begin with, there seems to be something odd in the contention that Everett's writing of the state of a 'real system' displays a set of 'possibilities'. After all, a debate took place between physicists who contended that a measurement yields transition from several possibilities to a single actuality, and Everett, according to whom all the elements of the superposition are 'actual'. But to understand Everett's position, one must

12. E. Schrödinger, *Eranos Jahrbuch*, 14 (1946) 491.

recognize that his primary concern was not to eliminate the concept of 'possibility' from the interpretation of quantum mechanics. It was rather to avoid considering any physical *transition* from the possible to the actual. And, since 'actuality' is usually considered as the most obvious characteristic of an experimental result, Everett had but one solution in order to eliminate the necessity of considering a transition: it was to spread out 'actuality' onto every term of the superposition. In the possible-points-of-view interpretation, the last stage of an experiment, its cognitive level, amounts to the identification of Mind to one of the possible points of view it can adopt upon the 'real system'. This identification is definitely not a physical process, not any more than Bell's 'attribution' of a beable is. It does not involve anything which would *change* the state vector describing the real system. However, at this stage, the reasoning remains incomplete. For, if Mind identifies itself *irreversibly* to one of its possible points of view, what difference other than purely verbal is there between 'identification' and 'actualisation'? Don't they both ascribe a particular status to one term in the superposition? To clear up the non-trivial difference between the two concepts, we need a precise spatio-temporal analysis of 'identification'. This analysis is likely to eliminate radically the possibility of speaking of 'identification' as if it were a 'process' able to occur 'reversibly' or 'irreversibly'. But before performing this analysis, I would like to study another difficulty.

A problem in the present analysis is that the modified perspectival description of the world we propose lacks a meta-level from which the points of view can be described. There is no "point of view of points of view" which would be able, as the Leibnizian God, to encompass the whole series of monads. Indeed, as soon as (abstract) Mind identifies itself with a point of view, it can but identify itself to a *particular* one. However, this being granted, the mere insistance on the "particularity" of a point of view sounds artificial. Since no point of view is available from which all the other points of view would be seen as equivalent, the point of view Mind adopts, when adopted, is not one among others; it is *the* point of view, self-referred to as *my* point of view.

Let me retain that (abstract) Mind, having no point of view of its own, can but adopt *particular* points of view and identify itself completely with each of them. Mind is by itself point-of-view-less, just as it is placeless and timeless. The aporia is the following: Mind is not within the world since, even if it can identify itself to any available point of view, it is not *identical* to this point of view. Nor does Mind stand outside the world, since it has no point of view of its own, independent from the points of view the world can offer. Wittgenstein would say that Mind is the limit of the world.

More formally, Mind can be considered as an empty space in the triadic relation: "point of view of ( ) on a 'real universe'". This scheme provides another way of seeing why Mind retains its necessity, even though the "real universe" gathers all that falls under the categories of knowledge: Mind plays a key role in the very *constitutive relations* of this knowledge. Its closest philosophical equivalents are Husserl's and Sartre's *Transcendental ego;* or, even better, Wittenstein's subject which "(...) does not belong to the world: rather it is a limit of the world" (*Tractatus* 5.632).

4. Changing world, Timeless mind.

Everett's wave function can now rightly be called, in the framework of the perspectival scheme, "a continuous representation of 'real objects' in space and time". Indeed (under a certain preferred decomposition), the wave function can display the whole set of "aspects" and (figurative) points of view which define the real object. It also allows one, through its evolution ruled by the Schrödinger equation, to predict the onset of available points of view in the course of a certain interaction. The wave function enables one to calculate the set of possible points of view defining a particular real system at time t, given its structure at time t' (generally, one takes t'<t, but the reversibility of the Schrödinger equation does not preclude t<t'). Howether, the last step of an experiment, cognition, 'identification' as I have called it, is not included in this description.

Indeed, since it involves a timeless entity, identification of the (abstract) Mind to a given point of view is definitely not a temporal process. It is metaphorically appealing to fancy it as a beam of light (of heavenly, non-disturbing light, of course!!) illuminating a particular point of view, whereas the other points of view remain in the darkness. But this is again misleading. No *thing* can give any distinct character to a point of view Mind has adopted, since every relevant *thing* is already included in the spatio-temporal description afforded by the wave function. In fact, Mind is the only entity concerned by 'identification'.

The strangest point is that, in this conception, nothing prevents Mind from identifying itself to this and that point of view, here and there, before and after. Mind has no spatio-temporal location, and It cannot be aware of any 'change' occurring while It performs the odd trip we have just sketched. Indeed, if It identifies itself to a given point of view, this implies that It adopts the whole associated memory content. It can never remember a "previous" point of view, for all its available 'memories' are confined to the particular point of view It occupies "presently". Of course, the words "previous" and "presently" have no other significance than to help giving an analogical picture of 'identification'. (Abstract) Mind has no history, and present, past and future are meaningless for it. Having a history would mean holding *traces* of a past. But all the possible traces are included in the description of the objective world, where they appear as (figurative) points of view. The only history Mind can have pertains to the point of view it identifies itself to.

More generally, the "direction of time" is a concept which can be shown to rely on the structure of memory in any (figurative) point of view, including information about other points of view[13]. (Abstract) Mind has nothing to do with that.

The difference between actualisation and identification is thus considerable. Actualisation is an irreversible (physical) process, by which one of the possible (figurative) points of view is selected, or given a distinctive status, so that any further description of possible points of view is dramatically affected by it. 'Identification' has no bearing with physics at all, it does not modify the becoming of the set of possible (figurative) points of view. Again, it is pure cognition. 'Identification' provides a

13. M. Bitbol, *Philosophy of science*, 55 (1988) 349.

connection between the objective world unfolding in space-time, and the placeless and timeless (abstract) Mind. But this connection is necessarily very peculiar.

For instance, it would be absurd to state that 'identification' (of abstract Mind) with a given point of view has occurred, say, at ten o'clock in the morning. For temporal location pertains to the objective world. It would be no less absurd to infer from this impossibility that 'identification' *never* occurs, since cognition would then prove impossible. 'Identification' occurs *now*. But what is *now?* Now is clearly no *given* time t. If its indexical status is taken at face value, it is usually given a 'token-reflexive' reference: now is the time at which the word 'now' is being uttered. But in the context of our present discussion, 'now' is merely the conventional answer one is bound to give to the question "when does the act of awareness of the abstract subject of cognizance (or Mind) occur?". In Schrödinger's words, "(...)it has a particular time-table, namely Mind is always now."[14] If this acceptation is retained, 'now' cannot be ascribed any proper location in time[15], not even by the method of token-reflexiveness; for the sound 'now' is a physical event, whereas the (abstract) Mind has been deliberately disconnected from any physical occurrence.

An interpretation of Everett's theory of measurement based on 'identification' occurring 'now', apparently gives some credit to Bell's contention that Everett only offers an account for correlations between *present* memories. However, I think Bell is wrong when he opposes Everett's attempt at associating "each particular branch at any past time in a tree-like structure" to his emphasis on "memory contents as the important thing"[16]. There is actually no contradiction between the two concepts: Everett's branched scheme is a representation of the 'real' objective world unfolding in time (in the sense of perspectival realism), whereas emphasis on the memory contents can be construed as expressing the point of contact between the objective world and cognition, through 'identification' occurring *now,* always now.

Similarly, Bell dislikes Everett's theory, because he thinks that "Everett's replacement of the past by memories is a radical solipsism (...)"[16]. By radical solipsism, Bell here means that not only, in Everett's theory, "I" am Alone, but also that "the present", token-reflexively considered as a particular time t, is Alone. I think that Bell's fear is not justified. I'd rather like to show that Everett's picture provides the most decisive departure from 'radical solipsism' one may wish, provided one is aware of the fundamental difference between the indexical term "present" (especially when it is hyper-indexicalized by its ascription to the awareness of an abstract Mind), and the name "time t". To see this, it is useful to recall a quantum mechanical account of time, first reported by Page and Wootters[17] and then analysed in Everettian context by

14. E. Schrödinger *Mind and matter* (Cambridge University Press, Cambridge, 1983), p. 145.
15. M. Bitbol, *Contextos*, VI/11 (1988) 7.
16. J. Bell, *Speakable and unspeakable in quantum mechanics*, (Cambridge University Press, Cambridge, 1988).
17. D.N. Page and W. K. Wootters, *Phys. Rev.* D.27 (1983) 2887.

Deutsch[18]. Let us consider the state vector $|\Psi\rangle$ of a 'real system' made of: an observer, its immediate surroundings and a clock. Let $|t\rangle$ be an eigenstate of a clock reading observable **t** (true, no "Universal Time" observable exists, see e.g. Pauli's arguments, but particular clock reading observables are not precluded). And let $|t\rangle|a(t)\rangle$ be the simultaneous eigenstates of **t** and of an observable **A** representing the rest of the system. According to Page and Wootters, it is possible, in quantum mechanics, to replace entirely the usual time dependence involving a variable t, with a steady correlation with some appropriate clock. Let then $|\Psi\rangle$ write:

$$|\Psi\rangle = \int dt\, c(t)\ |t\rangle|a(t)\rangle$$

In the possible-point-of-view interpretation of Everett's formalism, one can read this formula at two levels. At the first level, it accounts for the internal consistency of each (figurative) point of view, including any particular reading of the clock. Whenever Mind identifies with a certain point of view, it is thus bound to find itself in a completely coherent spatio-temporal web. At the second level, it displays the disconnection between time and now. Identification of Mind with a particular a(t) takes place 'now'; but nothing prevents Mind from identifying itself 'now' to *any other* a(t'). No narrow solipism focusing on a particular time t is involved at this point. Only an universal solipsism of 'now'. But just in the same way as the extreme solipsism of 'I' discussed in Wittgenstein's *Tractatus,* this extreme solipsism of 'now' can no longuer be distinguished from realism. "The self of solipsism shrinks to a point without extension, and there remains the reality coordinated with it" (5.64). Similarly, we could say that "The now of extreme solipsism is expelled from the space-time continuum, and there remains the manifold points of view of the (spatio-temporal) reality coordinated with it". To summarize, when the difference between the timeless 'now' and a particular clock time t is fully appreciated, it becomes clear that time-solipsism does not pertain to Everett's interpretation as such but only to a special reading of it.

5. Privileged points of view.

Bell's thorough criticism of Everett's interpretation also bears on another point. According to Bell, Everett kept something of the Copenhagen ideas, by making assumptions about the "complexity" of the observer's body or measuring apparatus. After all, a complete objective physical description of "reality" should avoid any reference to particular *extra-theoretical*, properties of observer's bodies. According to Bell, it should describe these bodies as a set of particles, interacting with other particles. Now, if any bias in describing the observer's body is thus avoided, some important characteristics of Everett's picture disappears. In particular, at the microscopical level, there are as much coalescences as there are splittings of branches, and one is brought back to Feynman's path integral concept. Bell is certainly right on this point. A theory of "real" objects should be able to encompass indifferently any kind of object, without

18. D. Deutsch, in: *Quantum concepts in time and space*, eds R. Penrose and I.J. Isham, (Oxford University Press, Oxford, 1986).

particular stress on the "complexity" of some of them. But to understand Everett's bias, one has to consider again the relation between the theory of "real" objects and cognition.

This can easily be done through the notion of 'identification'. Let us confront (abstract) Mind with a "real system" made of only two particles whose states are correlated, as a result of an interaction having taken place between them. Nothing precludes that Mind identifies itself to one of the points of view offered by this simple system. But this point of view does not offer to mind more than one item of memory. Moreover, this memory is likely to be lost through coalescence of the splitted branches. At any rate, it does not afford any possibility for Mind to put into practice the set of epistemological criteria which define objective knowledge, such as reproducibility of the experiment, and intersubjective agreement. Testing reproducibility requires at the very least two items of memory to enable *comparison* between the result of the first measurement and the results of subsequent measurements. It requires also intellectual capacity to evaluate similarities or differences. Testing intersubjective agreement needs capacity to communicate by *signs*. Identification of Mind to 'simple' points of view is thus not impossible, but in such a 'process', Mind has not gained anything like knowledge. It is only from points of view pertaining to sufficiently complex systems that self-conscious objective knowledge is reached by the (abstract) Mind.

To summarize, Everett's postulate of complexity is not needed in the possible-points-of-view interpretation of the relative state formalism. One only need a selection criterion analogous to the weak anthropic principle. The points of view pertaining to sufficiently complex systems (human bodies) are the only ones to be considered, because only from them can (abstract) Mind be aware of objective knowledge, theories, and the like. In simple points of view, the questions we have just dealt with do not even arise.

6. Indeterminism, choice and context.

A theory can rightly be said deterministic if two conditions are fulfilled. First, the theory must afford a set of laws allowing one to predict *univocally* the state of any object at time $t+\delta t$, from the state of the same object at time t. Along with this criterion, a version of quantum theory which only retains continuous development in time of the state vector according to the Schrödinger equation is obviously deterministic.

The second criterion is that the theory should allow one to predict univocally the result of an experiment, given the specification of the measuring apparatus, of the individual object on which the measurement bears, and of their initial *state*. Quantum mechanics is usually considered to be indeterministic according to this criterion.

The divergence between the two criteria is at first sight surprising. If any experiment could be given a complete description within the framework of the continuous approach of quantum mechanics, determinism according to the second criterion would be a mere consequence of determinism according to the first criterion. One is thus compelled to aknowledge that *something* in the experiments is out of reach of pure continuous wave mechanics. Many attempts at disclosing the nature of this

foreign "something" have been performed in the past. They go from the usual idea according to which the object is disturbed by interaction with the measuring apparatus in a way that is impossible to control, to the direct intervention of the subconscious (See Pauli's ideas[19]), or to (non-local) hidden variables. None of these attempts have proved fully satisfactory. For instance, the idea of a "disturbance", even though intellectually appealing, amounts to supposing that there was a property before the measurement and that it has been modified by the physical interaction with the apparatus. But the very notion of a pre-existing property has been criticized (by Bohr and Heisenberg) on the ground of this "disturbance" argument, which thus appears to undermine its own foundation. Moreover, nothing precludes that this "disturbing" interaction be accounted for within the framework of wave mechanics, and, when this is done, the system object+apparatus appears as a whole, in which properties no more pertain to such and such part of it. Here again, the "disturbance" view looks difficult to maintain.

In this situation, it is interesting to see that a new conception of the above-mentioned "something" which eludes the wave-mechanical description can be afforded in the framework of the possible-points-of-view interpretation of Everett's formalism. As we shall see, according to this interpretation, the said "something" is not only out of reach of a particular physical theory such as wave mechanics; it is identical to that which is necessarily excluded from *any* act of knowledge. As a consequence, indeterminism must not be looked for within the framework of the quantum formalism itself. This indeterminism is more likely to be the sign that the interpretation of quantum mechanics cannot avoid dealing with a basic epistemic boundary.

To begin with, I would like to make the provocative statement that, if the second criterion of determinism is adequately generalized in order to match the possible-points-of-view interpretation of the relative state formalism, then quantum theory turns out to be intrinsically just as completely deterministic as classical mechanics is. Let us then proceed to this generalization. A theory can be said to be deterministic according to the second criterion, provided it allows one to state a set of propositions of the following kind:

D1: "If you choose the experimental set-up E and the initial condition I, then you will certainly obtain the result R" (The concept of choice is not absolutely necessary, but it is interesting to make use of it in a first approach, because it helps revealing the relevant questions. Statements dispensing with the word "choice" will be discussed later.)

Now, using the spatial metaphor which proved so useful, the deterministic statement D1 can be changed into:

D2: "If you choose to adopt the point of view P, then you will certainly see the aspect A of the object you are looking at.".

Here, specification of P is equivalent to that of both E and I in D1. As for A, it is but the spatial transposition of R. This form D2 of the deterministic statement can easily be transposed to the case an extreme version of the principle of objectivation is adopted. In order to do this, we only need to substitute "Mind" for "you" (conceived as a

19. K.V. Laurikainen, *Beyond the atom*, (Springer-Verlag, Berlin, 1988).

"person"), "figurative point of view" for "spatial or experimental point of view", "identify itself" for "adopt", "is aware" for "sees", and "result R' " for "aspect A". The sentence then becomes:

S: "If Mind chooses to identify itself with the (figurative) point of view P', then it will certainly be aware of the result R' "

Now, let us suppose more precisely that P' specifies a particular memory content correlated to one eigenstate among a given set of eigenstates corresponding to some observable. We are then brought back to the possible-points-of-view interpretations of the relative state formalism. It thus arises that, in such an interpretation, the linear superposition which represents the state of an object in the restricted sense correlated with an apparatus and an observer's body, just corresponds to a set of statements S. This being granted, quantum theory appears to be fully deterministic, in an almost trivial fashion: if Mind chooses to identify itself with the (figurative) point of view (or memory content) which is partly defined by its containing the result R', it will obviously be aware of R'.

One must nevertheless realize that sentence S requires that a basic condition be fulfilled: "If Mind chooses...". But what can it mean for Mind to "choose" something? To answer this question, we must first examine the concept of choice in the usual situation where *you* perform it. You (person) are aware that you have made a choice, if you can compare the final outcome of your process of decision making, and the subsequent action, when the latter has been performed. Knowing the action alone is not enough, since this action can be the result of any other process than "choice". Remembering the process of decision making is thus a crucial requirement to give meaning to the concept of choice. However, it is not necessarily *your own* memory which is involved. If, for instance, you happen to be amnesic, a friend of yours, who was aware of your process of decision making, can remind it to you after you have performed the corresponding action. Your past decision can after all be made part of the objective world, just to the same extent as your action. As such, it can be *known* and remembered by somebody else.

But (abstract) Mind has no memory of its own. It has no memory which does not pertain to one of the points of view it may "choose" to identify to. It thus cannot "remember" any process of decision logically prior to this identification. More generally, no entity can possibly know Mind's process of decision making, if any. Mind, in the narrow acception we have adopted in this paper, is pure *knowing*. It is a pure pre-requisite for knowledge. It does not pertain in the slightest way to the domain of the *known*. Choice has thus definitely no meaning for Mind, since Mind cannot even be aware of having decided anything. Then, what about statement S, which involves comparison of a decision taken by the mind and the result R'? We could say that in a sense, it expresses a determinism that nobody can know, and especially not Mind itself.

The previous reasoning relies heavily on discussing the concept of choice. But it is by no means obvious that this concept cannot be dispensed with in the usual definition of experimental determinism. After all, the measuring apparatus could have been prepared through purely external circumstances, which owe nothing to any observer's volitions. Let us then examine another version of sentence D2, wherefrom any reference to "choice" has been removed:

D'2: "If you happen to adopt the point of view P, then you will certainly see aspect A"

The sentence may be analysed in the following way: the aspect A obtains on the background of a double context. A context which, at least in principle, can be modified (point of view P) and a quasi-invariant context ("You", your body, your personal identity, your memories etc...). For you can change your point of view without ceasing to be "you". This invariant context is crucial to give access to the full meaning of the sentence D'2. Indeed, it is only by remaining "you", the same "you", that *you* can *compare* several outcomes and points of view, and consider P as a *particular* point of view, which *you* could leave. This is true even if you do not personnally leave the points of view P, and rather get information about aspects A_i from points of view P_i, by asking other observers or machines which have adopted P_i. It is this possibility you have of comparing directly or indirectly the aspects you get from many points of view, while remaining the invariant context on which the comparison may be performed, that enables you to test the deterministic content of sentences D'2 on *several* tokens. And this is necessary, for the fact that a *single* token of D'2 is true could after all be ascribed to pure chance. (The concept of choice, as used in the previous version of the reasoning, had no other role than its implicitly involving such a possibility of comparison. If, before your decision, you were able to perform a choice, this meant that you could have taken another decision than the one you actually took.)

Let us now transform sentence S in the same way sentence D2 have been transformed into D'2:

S': "If Mind identifies itself with the (figurative) point of view P', it is certainly aware of the result R' ".

The fundamental difference between D'2 and S' is the following: there is no invariant context involved in S'. Mind can by no means adopt a point of view P', then a point of view P", and remember having been *itself* in P' when it is in P". Nor can Mind get indirectly the information concerning P" when it has adopted P': to whom could It ask this information? Mind, in the stronger acception of the word *identifies itself* with a particular point of view. It strictly adheres to a (figurative) point of view without any possibility to stand back.

Thus, there is no way by which Mind can test the deterministic content of a set of sentences S'. For Mind, the situation described by P', to which it has identified itself, is contingent and unique. Changing point of view, say to P", would only yield pure adhesion to it. P" would then be considered as contingent and unique as P' was.

To sum up, the incapacity of quantum mechanics to predict with certainty the result of an individual experiment does not result from an inbuilt indeterminism of the theory. It rather arises from the fact that the underlying determination cannot, even in principle, be mastered. It cannot be mastered by *the only knower which may be left outside the quantum account of an experiment,* namely (abstract) Mind (in the severely restrictive sense we have defined).

7. Fuzzy mind.

The possible-point-of view interpretation of quantum mechanics that I have advocated in the present paper bears some strong structural similarities with Squires' interpretation[20]. There are also major differences.

To deal with the fact that, in quantum mechanics, the outcome of a measuring interaction is a superposition of eigenstates, whereas only one of them is actually observed, E. Squires assumes that universal "consciousness" or "Mind" selects freely *one* of the terms of the superposition. But, by enabling the popular fuzzy components of the concept of "mind" to intrude into the analysis, the author is led to predict paranormal effects. To begin with, according to him, particular observers can consult the universal mind about other observers' states of "mind": this is "quantum telepathy". Secondly the "universal mind" can perform specific choices instead of "random selections" of eigenstates: this yields "quantum psychokinesis". My own paper can be construed as an attempt at reaching enough rigour in the definition of the relevant concept of "Mind" for any spurious justification of paranormal effects to become pointless. In the restrictive acception of the word "Mind" I used, namely that of pure *knowing*, or pure pre-requisite for knowledge, there is nothing to be *known* in Mind. Mind has no memory content of its own. Thus, in particular, no "observer" (or "point of view", in my own terms) can consult Squires' "universal consciousness" or "Mind" directly, if he/she wants to know another observer's memory content. No ground is therefore left for Squires' "quantum telepathy". For similar reasons, I noticed that the concept of choice is merely meaningless for Mind. Its "choices", if any, are bound to be blind. There is thus no way by which Mind could perform a *specific choice* among the available terms of the superposition of states. Hence, the absence of any ground for Squires' "quantum psychokinesis".

From a philosophical standpoint, Squires' conclusions follow from a very straightforward version of dualism. My view is rather related to a very softened version of dualism, which I shall call "functional dualism" (coupled with phenomenological monism). In such a doctrine, the notion of "knowing" is required in order to take into account the unavoidable incompleteness of any description of the known. The "knowing" has accordingly no other content than that of a mere name for incompleteness. It has no content, but it still retains a *function*: it is the "*to whom* " a result appear, or the "*by whom*" a physical structure of some brain becomes *experience*. At this point, it is worth discussing briefly another recent reading of Everett's interpretation, which is remarkably close to the one I am advocating although it rules out *any* version of dualism. According to M. Lockwood[21], the interaction which carries the observer's brain into a superposition of eigenstates yields a correlative differenciation of the streams of consciousness (or biographies) of the said observer. Along with this interpretation, Lockwood faces two main difficulties, that he fully acknowledges. The first difficulty is related to the self-referential aspects which undermines any identity theory. It is eschewed by a formal move towards dualism. The

20. E. J. Squires, *Found. Phys. Lett.* 1 (1988) 13.
21. M. Lockwood, *Mind, Brain and the Quantum*, (Blackwell, Oxford, 1989)

author of "Mind, Brain and the Quantum" calls such a move a "disclosure theory", whereby "awareness" is thought as "disclosing certain attributes of states of, or events within, our brains". The second difficulty is quite usual when dealing with Everett-like interpretations of quantum mechanics: why should the biography where I find myself privileged in any respect? This difficulty embodies the same kind of confusion, Lockwood argues, than the one which we face when asking "why is it now *now*?". I fully agree with the idea of conflating the two problems, but my solution to them is very different. Whereas, according to Lockwood, *now* is any *time* I am able to experience as present, I consider that *now* does not even belong to time[14]. Indeed, in the previous paragraphs, Mind was defined in such a limiting way that the pure fact of experience (of *its* experience) does not belong to the physical world, not even to its spatio-temporal framework. This abstract Mind therefore lacks both the continuity of a biography and the discontinuity of a time location: it can only have them as *contents* of experience, by identifying to the corresponding brain state. This is a reminiscent of Merleau-Ponty, according to whom *now* can be conceived metaphorically as a kind of point of view upon time.

8. Conclusion.

The outstanding importance of quantum theory for modern thought is likely to lie in its having led us to make coïncide the particular limit of a physical description with the general limit of objective knowledge. Quantum theory has also put such a strain on the concept of reality, that it has only left a choice between abandoning this concept or attempting a radical generalization of it. The possible-points-of view interpretation of Everett's relative state formalism lies right at the intersection between these two generalizations. It relies on an extended version of the perspectival definition of "real objects", and also on a limiting concept of the observer, namely the pure knowing subject.