THE NOW, RELATIVITY THEORY AND QUANTUM MECHANICS

Jean SCHNEIDER
CNRS-Observatoire de Paris
92195 Meudon FRANCE

1 Introduction

After many human conquests, time is still the potential subject of wide future explorations. It is an essential dimension of philosophical and natural sciences. As such it presumably touches the foundations of both domains and its study gives an opportunity to investigate their profound relationships. The present paper gives a synthetic presentation of published and unpublished work on the subject. Part of it consists in well demonstrated results; other parts of the work, although still in progress, can be considered as well established ; finally some propositions are conjectures requiring better support. The coming pages are therefore to be taken rather as the summary of a first attempt. From time to time I will be led to make some digressions in several domains: this shows that time is at the root of any fundamental interrogation as soon as it is investigated deeply enough.

2 The missing now of physics

2.1 The structure of the now

The so called t "variable" occupies a very singular position in the space of physical concepts. It is one of the most fundamental, but at the same time the most problematic parameter. Indeed a notion as evident as the "passage" of time is unknown in physics. There is no physical equation expressing that "time is passing", nor any physical device to measure this passage. But if we do not let ourselves be stopped by the negative aspect of this statement, its investigation can be the starting point of wide perspectives, at the borderline of physics and philosophy.

Let us be more specific. By describing time by the real number t, physics frozes this dimension since it ignores its processual aspect; in physics time does not pass. I will call, as it is usual in ontology, this aspect of time primitive or original temporality, or, in short, temporality. Physicists speak about the t

"variable", but they do not say with respect to what this variable is varying. It must be realized that this transitional time is different from irreversibility as it is expressed by the second principle of thermodynamics. Authors like I. Prigogine[1] claim that the second principle is a formulation of the passage of time. It is in my view a misunderstanding since all what the second principle says is that entropy is a monotonic function of t, but it is unable to express that the instant denoted by t has to be always new. The so-called "creative" content of thermodynamics of irreversible processes (i.e. the local decrease of entropy by amplification of statistical fluctuations) is a decoy which attributes to the discourse of physics aspects of time, which in fact belong to the natural language in which the laws of thermodynamics are popularized.

This negation of time becomes even stronger by the fact that in physics there is no "now". The existence of this word is in fact problematic. As a word designating the present instant, the instant where it is pronounced, the reality designated is never the same. There is a contradiction between the permanence of the *designans* and the variability of the designated. I will give below some elements of formalization of the "now"; this project of a formalization strengthens this contradiction. We must nevertheless not let ourselves be paralyzed by this situation. One can find similar contradictions in the formalization of the zero, of the infinity and of the negation. Is it indeed not contradictory to want to mark by a special sign, namely 0, the nothing, the absence of sign? In a similar way is it also not contradictory to formalize the infinity with a finite number of signs? Finally there is a contradiction in the formalization of negation since to write down **non A** means "I do not write down (**non A**) what I write down (**A**)". It is the gesture of formalization itself which is problematic, but we must accommodate ourselves to this situation. I will show indeed that, if we are not able to formalize the present itself, we can nevertheless describe its production. In other words, one cannot write down that a point on the worldline is actual, but we can formalize the process of actualization of the now since it is permanent.

The flow of time does not exist by itself. We can reach it only through operational mediations. This methodological position is in harmony with the spirit of sciences of this century like relativity theory, quantum mechanics or psychoanalysis. We do reach things only by the means of some "apparatus": physical clocks for the chronological time, macroscopic measuring devices for quantum systems, free verbal associations for the unconscious. As to the flow of time, if it escapes physics, it is not unutterable since we do reach it through a privileged "instrument", natural language. The latter must be considered here not as a system of notations but as a process of production of signifying units (which I will designate by the word *significans*). A (passing) instant is thus the lapse of production of a *significans*. To recall the classical analyses

[1] See for example: *Order out of chaos: man's new dialogue with nature*

of Benveniste[2], the "now" does not designate any particular point at rest on a worldline; it refers to the temporal context of its own production. We should consider as valid the equation: "now" = production of "now". This situation was already characterized by Benveniste as *self-referential*. What is important here is that it is impossible to describe it in the traditional framework of physics. It is made possible only thanks to the structure and to the immaterial character of the meaning of a *significans* . At this point I beg the reader to allow me to take an enormous short cut: what is true for the "now" is true for any *significans*. The latter is not, contrary to the spirit of information theory, just a one by one correspondence between a sign and what is designated by it, a *significans* is always coextensive to its own production (that is why this latin word is a verb and not a substantive). A written text is just a structure statically layed down on its medium; it takes a meaning only insofar as a reader brings it up to the universe of meaning. In this way "meaning" is the same as "creation of meaning", a statement by which we see its self-referential nature. We must therefore complete the statement of de Saussure "the *significans* develops in time and has the charateristics that it borrows to time"[3], by its inverse: "time has the characteristics that it borrows to the *significans*, to be its own production".

One could think that this creation is compatible with the *datum* of a time axis which one could articulate to the meaning in a sufficiently judicious way. I have shown elsewhere[4] the weakness of this solution and have proposed another one. As the word expresses it, an instant is unstable, never at the same place, in perpetual dis-placement. It is therefore at the same time a benchmark and the displacement with respect to it, i.e. to itself. Thus an instant a is a transition, the transition between itself and another, b. This intuitive statement can be formalized in a rigorous way, either in terms of Combinatory Logic (for instance in the version developed by F. Fitch[5]) or perhaps of hypersets[6]. Let me stress that a formalization is not a pure exercise of style; experience shows that it is sometimes more appropriate than natural language to describe intricated situations and that the development of calculations can make one discover ideas which were not visible at first sight. Irrespective of the technical considerations[7], the idea is to express the passage of an instant as:

$$a = a \to b \qquad \text{or} \qquad a \overset{a}{\longrightarrow} b \qquad \text{or} \qquad a = (a, b)$$

[2]in *Problems in General Linguistics*

[3]in *Third course on general linguistics*

[4]in *The self-referential structure of temporality*

[5]in *Elements of Combinatory Logic*

[6]Or "non well-founded sets" since they do not satisfy the "foundation axiom" of set theory which leads to forbid expressions like $x \in x$. See P. Aczel: *Non well-founded sets.*

[7]Developed in *The logic of self-difference*

or, better, by:

$$a \qquad b$$

Let us make a pause in the formalization effort and consider a first series of qualitative comments. First of all, after having drawn the self-referential structure of temporality, I will suppose inversely that where there is self-reference there is temporality. Secondly, as I will show later on in the text, the relation $a = (a, b)$ implies that the transitional time is necessarily discretized, i.e. fractionated in discrete units. In other words, to each transitional instant is attached a certain finite chronological duration ΔT. The value of ΔT depends on the kind of *significans* which gives access to the associated transitional instant.

Let us consider for a while the possible minimum value for ΔT. With this discussion we stand at the crossroads of two conceptions. The feeling of the continuity of time and the fact that we are used to consider durations of the order of milliseconds or microseconds or less, can lead us to envisage the hypothesis that ΔT is a very short fraction of a second. Any physicist would normally be tempted to attribute to ΔT the value of the Planck time[8]. But on the other hand I accept the axiom according to which temporality can only be reached by the means of meaning, itself actualized by a *significans*. Thus ultra-small values for ΔT would be possible only if there is in some way a (meaningful) *significans* attached to ultra-short phenomena. Such phenomena of meaning are not known to our consciousness. If we want to consider them as possible, we should have to assume their existence, to postulate some kind of "infra-meaning". The condition for an evidence for such an infra-meaning would be that the observer would have with the system relationships belonging to the universe of meaning with very short durations. The different types of unconscious levels considered by psychoanalysis (primary, original) seem not to fit to such an infra-meaning. Furthermore although there is, for each type of *significans*, a finite value for the minimum of ΔT associated with its self-produced transitional instant, one could mathematically consider a passage to the limit procedure, such that the lower bound of all ΔT's is zero; one could for instance postulate that $a = \lim_{b \mapsto a}(a, b)$, where $b \mapsto a$ means "b goes to a". Although empirically the minimum value of ΔT lies between 0.1 and 1 sec, such an hypothesis cannot be definitely ruled out. We have indeed to be aware that this situation may be provisional and not to fall in excesses of phenomenology. For instance the arbitrary apparition of language in the history of Humanity should be a lesson leaving open the possibility of future infra-meanings attached to phenomena as short as a μsec or less. The future evolutions[9], for instance in the domain of virtual reality or of bio-cybernetics with the help of nano-technologies, may indeed lead to surprises: does experi-

[8] It is a combination of the fundamental constants of physics and its value is 10^{-43}sec.

[9] It is hazardous, or even paradoxical, to speak about future in a context destinated to reshape the notion of time. I have treated this paradox in *What will time become?*

ence not show that the meaning can come from pure habit[10] ?

But today we do not stand that far. I will start by taking note that there is no signifying event or phenomenon lasting less than about a tenth of a second, thus discarding any infra-meaning. That leads us to take $\Delta T \approx 0.1$ sec. It is the chronological duration of the shortest semantic units we know, the phonems, called by Jakobson the quanta of language[11]. The affirmation that a minimum for ΔT exists and the value of this minimum do raise some questions: why 0.1 sec? can this value be derived from some basic principles? could it be empirically zero? etc. Shorter time intervals considered in various experiments in perception psychology (down to milliseconds) are reaction times measured by the methods of physics, but for the individual no subjective meaning is associated with them. I claim very clearly that we will not understand anything more to the transitional time by tracking shorter and shorter reaction times in experimental psychology. But why 0.1 sec? Is it possible to deduce this value from some basic principles in physics, in psychology or in philosophy? One easily conceives that the condition for the production of a signifying phonem (like the word "a" for instance), is that their underlying physico-chemical processes last a significant fraction of a second. There is no theoretical principle forbidding that a meaning is attached to phenomena such as an atomic (a few picoseconds) or even a nuclear (a few femtoseconds or less) transition. We are therefore led to consider the value of ΔT as a postulate of purely empirical origin, as fundamental as the speed of light or the Planck constant.

The philosophy underlying the self-referential model of time rests on a *twofold time*: the constructed "physical" time and the transcendental time of the transition $a \to b$. This twofold time enables us to give a ground to the intuitive notion of the "velocity of the flow of time ". The speed V_F of the flow of time establishes a relationship between these two times. It is the quantity of chronological time ΔT per unit of produced transitional time τ:

$$V_F = \frac{\Delta T}{\tau} \tag{1}$$

To the question "what is the speed of the flow of time?" the answer is: "about 0.1 sec per transitional instant". In fact the value of ΔT depends on the type of *significans* which "measures" the temporal transition. Time flows at different speeds depending on whether the signifying register is language, music, annoyance... It is probably necessary to add the notion of *investment* of a *sig-*

[10]It would be interesting, to clarify the role of ΔT, to find other forms of life in the Universe constituting potential physiological supports for a psychical activity. It is therefore urgent to accelerate the searches in this domain of astronomy presently poorely developed. For an up-to date information see A. Léger: *The mission Darwin for the search of primitive life on exo-planets* and J. Schneider *On the detection of habitable extrasolar planets: an overview.* For a philosophical discussion see J. Schneider: *Anthropology and space conquest: an essay in philosophy-fiction.*

[11]in *Six lessons on sound and meaning*

nificans: it is the most invested *significans* which has the highest weight and which imposes its value of ΔT and therefore its rate of time flow. If I listen to a speech, either I grasp its global meaning τ in the course of its duration ΔT and the time flow is rapid; or my comprehension blunders each of the N words in the same time ΔT and the speed $\Delta T/N\tau$ of the time flow is slow, generating annoyance.

This view may appear so anthropomorphic that this extreme attitude may seem to ruin the whole approach. To clarify this point let me invoke an analogy with the Joule constant J. It establishes, by the relation $W = JQ$, a correspondance between a mechanical quantity W, and a thermal quantity Q. The latter is not a fundamental dimension in physics, like mass, length, time or their combinations. However, the use of a heath quantity, which has an arbitrary physical dimension, is quite convenient since it is directly related to sensitive notions like cold and warm. In this respect, ΔT has the same status as J. This analogy has some limitations since an amount of heath can be determined with precision, whereas the value of ΔT is not rigorous: it is some sort of average, depending on one's mood. All shorter durations are purely abstract constructions, by the means of the discourse of physics, and do not concern the "real" transitional time. The existence of ΔT and its value of ≈ 0.1 sec, are finally as arbitrary and mysterious as the arbitrariness of the *significans* of de Saussure. And, as in the case of the linguistic sign, we must take them as given and try to work with them. Moreover, this mystery probably refers more fundamentally to the mystery of the kantian *scheme* of the understanding. The latter was conceived by Kant as "an hidden art in the depths of the human soul and from which it will always be hard to pull out the true mechanism to nature, to exhibit it openly to our eyes"[12].

2.2 From the now to the time-axis

Let us come back to the formalization. Existence is not made of *one* instant, there are *many* instants. How shall we articulate them? Let a, b, c, d, e,... be a collection of passing instants. As transitional instants, each of them is self-referentially related to another by a formula of the type $u = u \to v$. Let $\Re$ be the relation between two instants x and y defined by: $x\Re y$ if there is a chain $x = (x, t_1)$, $t_1 = (t_1, t_2)$, ..., $t_n = (t_n, y)$ linking x to y. $\Re$ is a partial ordering, i.e. a transitive relation. It allows to call y a successor of x or to say that y comes "after" x. In particular if $x = (x, y)$, y is an *immediate*

[12]in *Critique of pure reason*. I take this opportunity to make a remark about the scheme. It is a necessary go-between from the sensation to the transcendental concept. But the logical necessity leading to introduce this go-between leads to introduce a second one, between the scheme and the concept, an intermediary of intermediary. One is on the way of an infinite series of intermediaries. The most economical way out is to put the scheme into the concept itself (by the same way that the motion is, I believe, inside the instant), leading to the formula: $C = S \to C$: the concept, C, is the intermediary (and as such is the scheme) between the sensation, S, and itself. I will come back later to these considerations *à propos* the mind/body problem.

successor of x. It is easy to show that a given x can have only one immediate successor[13]. Therefore there can be no z such that $x = (x, z)$ and $z = (z, y)$; otherwise x would have two immediate successors, y and z. Thus there is no z "in between" x and its immediate successor y. This justifies the terminolgy introduced and shows that the collection of instants is discretized, in other words that there is a quantum of time ΔT. But at this stage nothing prevents to have the same successor y for two different instants x and x'; in this case the relation $\Re$ is not a *total* ordering. In other words, such a y would constitute a *bifurcation* of time, as shown on the following figure:

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These purely formal considerations bring us back to a problem arising in the reading of *Zeit und Sein* by Heidegger. He seems to indicate that the structure "past-present-future" of time (with no bifurcation) lets itself be deduced from the gift structure of original temporality suggested by the analysis of *"Es gibt Zeit"* ("there is time" = "there is donation of time")[14]. But as has been demonstrated above, and it is a benefit of our investment in the formalization, the transitional time is compatible with a bifurcation at each instant. If one wants to reject this bifurcation and if one requires the predecessor of each instant to be unique, we must impose this uniqueness by an explicit postulate. Why it is so is a question with no answer at the present stage of the query. It may be a consequence of some economy principle.

Let us any way assume, provisionally, that time is indeed without bifurcation. The relation $\Re$ is then a total order and the collection a, b, c, d, e, ... is structured in the following way:

$$a = (a, b), \;\; b = (b, c), \;\; c = (c, d), \;\; d = (d, e), \;\; ... \tag{2}$$

Graphically:

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[13] Because otherwise on would have $x = (x, y)$ and $x = (x, y')$, and thus $(x, y) = (x, y')$; now, according to the standard definition of a pair, $(x, y) = (x, y')$ implies that $y' = y$.

[14] "Thought from the threefold "presentation" (i.e. offering), the true time reveals itself as tridimensional", in *Zeit und Sein*.

It follows that the chronological time is the counting of this linear series of "pauses", ordered by $\Re$.

It remains to justify the numeric representation of time by physics, allowing for arbitrary small durations. The answer is quite obvious. $T = N \times \Delta T$ is the chronological time interval between the instants t_1 and t_N of a series $t_1 = (t_1, t_2)$, $t_2 = (t_2, t_3)$, ..., $t_{N-1} = (t_{N-1}, t_N)$. The usual procedure introducing a continuous time in physics then goes as follows. The velocity of a body covering a distance D in a time T is defined by $V = D/T$. The everyday observation of fast moving bodies leads, by inversion of the latter relation, to define time intervals of duration $\delta T = \delta D/V$ which can be arbitrarily small for sufficiently large velocities. These durations are always *calculated*, never "perceived" as passing time. Therefore the so called "physical time" is a purely constructed time. This construction is legitimated by the successes of physics, it just forgets the passing aspect of time.

2.3 Further implications of the structure of the now

Let us briefly recall other consequences and interpretations of the formula $a = (a, b)$ already developed elsewhere[15].

First of all it solves the Zeno paradox, proving from the representation of instants by points that motion is impossible, since it includes the motion into the instant itself. It must be stressed that here motion, symbolized by the transition $a \to b$, is *not* a derived quantity; it is a primitive concept, self-referentially related to the start and the end of an instant.

One of the important characteristics of the relation $a = a \to b$ is that the term a is at the same time an object, entering the transition $a \to b$, and the operation itself, since $a \to b = a$. We discover here a new type of logic, the non-stratified logic[16], for which an object x can be equal to a relation $R(x)$ bearing on x itself: $x = R(x)$. This non-stratified logic will later on be useful as a conceptual lancet to clarify some questions.

Viewed as the transition $a \to b$, the instant a is an interval. But it is also the beginning, the starting "point", of the interval and as such is ponctual. We therefore have a point which is a segment. This makes one realize how far the de-geometrization of the representation of time has to go. It gives a rigorous meaning to several notions of the philosophical tradition: the $\delta\iota\alpha\sigma\tau\alpha\sigma\iota\varsigma$ of Plotinus[17], the *distentio animi* of Augustinus[18], the *Ausdehnung*, the *Erstreckung* and the *Spanne* of Heidegger[19], the *internal tension*[20] of G. Guillaume[21];

[15] in *The self-referential structure of temporality* and *The logic of self-difference.*

[16] This notion of non-stratification has been proposed by Curry *et al.* in *Combinatory logic* p. 304.

[17] in *The Enneads III, 7*

[18] in *Confessions, Book XI*

[19] in *The Basic Problems of Phenomenology* secs. 19-20

[20] Which sheds light on the word *tense.*

[21] in *Time and Verb*, pp. 15-16 *sqq.*

finally Maldiney remarks the rip which is at the etymological root *Zit* (= to rip) of *Zeit*[22]. All these formulations are somehow inadequate because of their geometric connotations. We see here a new benefit of the effort of formalization: the nature and the structure of the non-geometrical character of the transitional "stretched" instant are completely clarified so much that they can lead to calculations, as we have seen. Let us note that such a stretching is considered in models of psychology, but in a non-rigorous way[23].

In the formula $a = (a, b)$, a is, as a symbolic entity, *one* term. But as it is the pair (a, b) intuitively represented by the transition $a \to b$, it contains *two* terms. The equality between a and (a, b) leads to put down the non arithmetical equality, in the sense of the set $\mathbf{N}$ of natural integers, *one* = *two*. This relation, to which a rigorous formal meaning can be given, is the first step toward a "proto-arithmetic", which can be fully formalized, arising when the counting is applied to self-referents, or non-stratified objects. The formalization currently attempted to understand these proto-numbers[24] is in well harmony with the notion of *dual unity* introduced in psychoanalysis by I. Hermann and developed by N. Abraham[25]. It means, according to the latter, the operation of fusion/de-fusion characteristic of the primitive mother/child link. The relation $a = (a, b)$ fits perfectly to the logical structure of the dual unity and allows to get rid of the geometrical metaphors used in its descriptions in natural language. An important question arises at this point: is the close relationship between the logical structures of dual unity and of the transitional time fortuitous, or does it reveal a real deep link? As already indicated by N. Abraham, dual unity is presumably at the root of transitional temporality: temporality is the mark, or the consequence, in the psychical order, of the corporal disposition of the child in the move of distinguishing itself from its mother[26].

The non-geometrical interval separating a from b lasts, in chronological terms, some time ΔT. But it is a lapse which ignores the passage of time, otherwise there would be an instant in between a and b, which has been demonstrated above to be impossible. There is thus a *suspension* of time[27] in the course of the interval. This suspension is as well a timeless *gestation* of the term b of (a, b), which may remind the "time of the out-time" introduced in a different context by P. Fedida[28]. This idea of gestation points to a feminine time, especially when associated with the notion of internal time introduced in linguistics by G. Guillaume[29]. It raises a question: how does the new instant

[22] in *Aîtres de la langue et demeures de la pensée* p. 3

[23] See for instance *Models of psychological time* by R. Block.

[24] See J. Schneider *A paradox in Combinatory Logic: one = two* and One = two: Introduction to a proto-arithmetic.

[25] in *The Shell and the Kernel*

[26] in *The Shell and the Kernel*, to be published. For a preliminary introduction, see *The Shell and the Kernel*, in *Diacritics*

[27] In holding someone *in suspense*, it is the semantic time itself which is suspended.

[28] in *Time and negation*, p. 442

[29] in *Time and verb* p. 16

in gestation know that the lapse ΔT is over? This question comes probably from the metaphorical way of its expression. It does not arise in the formal version of the model. All in all we get a dialectical entanglement of continuum and break whose sexual character will not escape to the reader.

3 Irreversibility

One of the great questions about time in physics is to understand why it is irreversible. It is less easy than it generally looks at first sight to express what is to be meant by irreversibility of time. Let us for the moment restrict our discussion to physics. The most current view is to define irreversibility in terms of the *increase* of entropy. But with respect to what does entropy increase? With respect to a predetermined direction of time which appears to be in the mind of physicists, by reading the textbooks, the direction of the time flow which they do not question. More specifically the question raised by irreversibility comes from the contradiction between the symmetry of the laws of mechanics with respect to the time reversal $t \to -t$ and the monotonic variation of entropy. Physicists have tried several ways to understand this problem. They have searched the explanation in statistical mechanics, in cosmology, in the $T-$violation of the K^o decay in particle physics, in the irreversibility of the quantum measurement. I do not intend to discuss these matters in details, I will rather present, after a few remarks, my own view on irreversibility.

In the case of statistical mechanics, O. Costa de Beauregard[30] has pointed out that, in the course of the demonstration of the $H-$theorem, one does in fact *postulate* a direction of time in the use of the before and the after of the collisions used in the Boltzmann equation. Together with other physicists, he has tried to get new insights in this question with the help of information theory. After E. Schrödinger[31], M. Bitbol[32] has proposed to radically avoid the notion of time thanks to the information at the observer's disposal. But one can remark that, without contradicting the views of this author, the notion of information itself does already contain time since to inform is to give a form, to raise to a new level of knowledge.

In cosmology it is customary to relate the direction of time to the direction of variation of the radius of the Universe, namely to its expansion and to ask "Why do we explore the time dimension of the 4-dimensional geometry in the direction of dilatation of the Universe?". This correlation is probably fortuitous: in an eventual recontraction phase, the direction of exploration would probably not be reversed.

Concerning the time-asymmetry of the transition $K^o \to \pi\pi$, it cannot alone change the entropy of a system since the global evolution operator is unitary in spite of this asymmetry; it is only when it is associated with an out of equilibrium distribution that the change of entropy can arise, and then we are

[30] in *Time, the physical magnitude*
[31] in *Irreversibility*
[32] in *The direction of time and the observation process* p. 89

brought back to the discussion of statistical mechanics. As for the irreversibility of the quantum measurement process, I will discuss it later on.

Where is then the true root of irreversibility? The answer that I propose rests on the remark that the physical time is only a construction starting from a more primitive time, the transitional time. As it is evident from the expression $a = a \to b$, an instant is intrinsically asymmetrical since $a \to b$ is different from $b \to a$. The instants are vectorized from their inside. The physical time (represented by the real number t) contains no such intrinsic asymmetry; the equations of physics may be symmetrical with respect to its reversal, it is the transcendental, transitional, time to which the observer, as a semantic being, has access, which is asymmetrical. This time is irreversible because it is entangled with the irreversible production, the inscription, of a *significans*. Why is this inscription irreversible? It is the third mystery that we encounter since we could as well write $a = b \to a$; nothing forbids, on formal grounds such a relation. Why, to borrow the language of Heidegger[33], can *Wesen* (being) only be *Anwesenheit* (pre-sence/ap-parition) and not *Abwesenheit* (absence/dis-parition)? We do perhaps reach here a limit of writing.

4 Relativity of the now

Compared to the transitional time, which is the true time, the t variable of physics is purely fictitious insofar as it is constructed by the means of, sometime very indirect, conceptual schemes. The measurement of an interval inferior to 0.1 sec never is a direct measurement of a duration; one does never measure such time intervals otherwise than by measuring another physical quantity, such as a length or an electric tension which is afterward mathematically converted into a time interval.

The discretization of time that we have shown to be a consequence of transitionality breaks down the relativistic covariance. This breaking was already recognized by A. Grünbaum[34] in a confrontation between Relativity and the becoming. He deduced that the becoming cannot be discretized. I would rather take an opposite view: we have to abandon its relativistic covariance. Indeed the access to becoming is possible only through a particular instrument, the *significans*, either linguistic or of any other kind. But natural language, as it is shared by the community of those having access to it and which is at the root of the passage of instants, creates a preferred frame of reference, thus violating the principle of relativity, *in the Universe of discourse, not in physics*. To justify this statement I shall invoke what R. Jakobson calls "the intimate union between sound and meaning"[35]: there is a (verbal) meaning only insofar as is it supported by sounds and this intimate union counts for

[33] in *On Time and Being*

[34] in *Relativity and the Atomicity of Becoming.*

[35] in *Six lessons on sound and meaning*

any other signifying order, each one having its type of support. It results that, in a moving frame, phonems, as acoustic phenomena, are stretched or contracted (by Doppler effect), but then, as signifying units, they are no more comprehensible, out of the universe of discourse in which physicists live; they loose their nature of *significans*, forbidding the access to the "now". There is no more transitional time. One could argue that it is always possible to record a signal distended or compressed by Doppler effect and to replay it later on at the appropriate speed to make it comprehensible and thus to recover the sense of transitional time. But due to the discretization of the latter, for a given amount of time the exchanged information and the attached meaning are not the same. For a sufficiently large relative velocity, for a given timespan even not one single transitional instant can be recovered. That justifies the privileged frame of the commonly shared universe of discourse. The real time considered by Bergson[36] which is the transitional time, is different from the physical, purely constructed, time. It is transcendental with respect to it and to the objects of physics. It is in this sense that the bergsonian "durée" is restricted to a privileged frame. In the Bergson-Einstein controversy, this rather rehabilitates the philosopher, or at least demonstrates how far the two interlocutors did speak about different things.

5 The quantum measurement

5.1 The semantic wave packet reduction

The irreversibility of time usually takes an important role in the discussion of the measurement in quantum theory. The interpretation of quantum mechanics still gives rise to debates about the nature of the quantum measurement. The reflexions on time developed above allow to contribute to the current discussions. Let us briefly recall where the problem lies. The central question is: "Why does the process of observation (giving rise to the wave packet reduction, that is to a sudden transition between two states of the observed system) escape to the normal evolution of the ensemble system+observer described by the Schrödinger equation?". There is an even more elementary question: "The knowledge of the state $|\psi>$ of the system is necessary to predict the possible outcomes of the observation; but it is not sufficient since to describe the set of outcomes we need to add an heterogeneous element, the operator associated to the observable which is measured. Why is this second level necessary?". I shall call it the "question of the concept of observable".

Several solutions have been proposed during the past years, each of them modifying in a way or another the foundations of Quantum Mechanics: hidden variables, spontaneous localization, non linear Schrödinger equation... As it is known, a significant step has been made by J.S. Bell[37] who has shown

[36] in *Durée et simultanéité* and *Matter and Memory*; for an account of Bergson's philosophy see M. Capek: *Bergson and Modern Physics*

[37] in *Speakable and Unspeakable in Quantum Mechanics*

that the assumption of a class of hidden variables would contradict the predictions of the standard quantum theory; the experiments by A. Aspect *et al.*[38] have given right to Quantum Mechanics. A different solution, known as the decoherence theory, has been proposed by W. Zurek without any change in the standard postulates[39]. It consists in remarking that the interaction of the system with the environment diagonalizes very rapidly, with a characteristic time τ and in an irreversible manner, the density matrix of the meta-system system+observer+environment[40], thus leading to an effective quasi-reduction of the wave packet. My purpose is not to make here a detailed discussion of the interpretation of these calculations (incidentally undisputable). I would just like to remark that:

1. the simple fact of invoking irreversibility arguments must make us circumspect, because they can suffer the same criticism as the one invoked by Costa de Beauregard when he points out the weakness of the "demonstration" of the H-theorem.

2. the value of τ depends on the coupling constants of the interaction of the system with the environment; thus, unless the observability itself constrains these constants, the value of τ is factual and the decoherence theory of the wave packet reduction cannot be a fundamental theory.

3. it does not at all answer the *question of the concept of observable* as raised above. A true completely quantal model of measurement should build the operator associated with an observable uniquely from the Hamiltonian of the the meta-system system+observer.

4. it is not sure that the decoherence theory explains why there is a choice between the different possible outcomes for a single specimen of a system.

Our analysis of the problem will go back to the question "What is really a measurement?". In addition to the indispensable material device, an observation needs at the end a gesture of inscription of the result in mathematical symbols. A measurement is a measurement when the physicist, or its apparatus, has writen down the result as a number or as any other symbol. As shown by the practice of physicists, the statement that an observable A "takes the value a" consist in the gesture of writing $A = a$. This gesture has nothing "psychological" insofar as it must be understood that it takes place in the restricted universe of discourse of the mathematized concepts of physics. These remarks lead in a natural way to the solution I propose[41]: the measurement act is not a physical transition or phenomenon, but a purely semantic act, in the same line of the *speech acts*[42] well known in linguistics. A speech act does not describe a situation independent of itself, it creates what at the same

[38] in *Experiments on Einstein-Podolsky-Rosen correlations with pairs of visible photons*

[39] W. Zurek: *Environment-Induced Superselection Rules.* See also R. Omnès *Consistent Interpretations of Quantum Mechanics* and Hartle and Gell-Mann *Quantum Mechanics in the Light of Quantum Cosmology.*

[40] At least in particular cases.

[41] See *Measurement act, speech act*

[42] For a general introduction to these notions, see J. Austin: *How to do things with words* and J. Searle: *Speech Acts: an essay in philosophy of language* .

time it describes. The measurement act has more precisely the structure of an *attribution* as defined below. The question whether this process is of psychological nature or takes places in some Mind is not relevant. A semantic process is exterior to any individual, it is existing only as shared by the community of locutors and in this sense is objective. It just takes place in a symbolic Universe, the Universe of discourse in which all physicists live. This is for instance the Universe studied by linguistics and semiotics. It has nothing to do with psychology. It is not the "consciousness" of the observer which operates the wave packet reduction, as was proposed by London and Bauer[43] and by Wigner[44]. It is the result of an impersonal, non psychological but empirically ascertainable, production of a *significans* which exists only as shared by the community of physicists[45]. In other words it is not a passive registration, it is an *active* semantic process. The subjectivity of one observer is to be replaced by an intersubjectivity of the discourse, with no psychological subject, where the impersonal semantic collapse of the wave packet takes place. This is how functions the symbolic sphere. To express it in another way, the measurement act, as giving an attribute to an system, is an act of attribution, a predicative act. The juridical domain can help us for an analogy: a judgement does not register afterward a pre-existing reality, it does create it by its verdict. Thus when authors like R. Haag[46] or E. Ruhnau[47] suggest that in the quantum measurement consists in a transition from potentialities to an actuality, this point of view is acceptable insofar as this actualization is strictly semantic. And to refer to the question underlying the Penrose's statement: "Quantum theory is silent about when and why the wave packet reduction R should actually take place"[48], the answer of the semantic collapse conception is: 1^o) the apparition of R is "without why", it is causeless, as it is the case for all symbolic production 2^o) it takes place when its symbolic inscription takes place. The result of that act is of course random and has a probability of occurence $| < a|\psi > |^2$. This conception sheds a new light on causality in the quantum measurement: the result of a measurement act has no other cause than itself, it is its own cause. It is in this respect that there is no quantum causality.

The "classical" character of the measurement apparatus lies in the semantic nature of its description, not in its complex atomic structure (as could naturally but erroneously be infered from the Ehrenfest theorem). A system is a measurement apparatus only insofar as it is described by a set of *significans*; otherwise it is nothing but a quantum system. As for the observer, it is most certainly made of atoms, but it is an observer only as a support of semantems. In a measurement, the so-called interaction with the measuring

[43] in *The theory of observation in quantum mechanics* p. 252

[44] in *Remarks on the Mind-Body question*

[45] According to modern views, consciousness is on the contrary defined as being the crossrads of different *significans*.

[46] in *Fundamental Irreversibility and the Concept of Event*

[47] in *The Now: A Hidden Window to Dynamics*

[48] in *The Emperor's New Mind* p. 297

apparatus (which would be described by an Hamiltonian) is an encounter, an interaction if one may say so, between the observed system and the universe of discourse. Because this encounter is not describable by an Hamiltonian the measurement process escapes the Schrödinger equation. It was Bohr who was among the first authors pointing out the role of language in the measurement[49]. But for him language was just a collection of words, the vocabulary of classical physics. Here the point view is different: what is important is not so much the *content*, but the *auto-productive* nature of a *significans* and it is this auto-production which gives rise to the wave packet reduction. The new perspective comes from the application of the resources of linguistics to the study of this process. Evidently every system cannot be a measuring apparatus. Which ones are and which ones are not apparatuses is an empirical fact which cannot be derived nor explained and which refers perhaps to the problematic and the mystery of the kantian schematism.

A *significans* is its own end, contrary to information which is always relative (one can only define a difference of two states of information). It is self-referential and there is in this respect something absolute in it. That is why it is necessary to stop somehow the endless series of observers (as stressed for instance by M. Bitbol[50], where each one observes the preceding in the series, arising when one tries to describe the measurement by an interaction Hamiltonian for the system-observer meta-system. One may perhaps start from the Wheeler's attempt to include the observer in the wave function[51]. The semantic collapse model pushes to go further. If the result of a measurement is, as a *significans* homogeneous to its own production, we are lead to tentatively equate somehow the result and its production. Let us attempt a formalization of this suggestion. The result of the observable A gives rise to the final state $|a>$; on the other hand the process of production of the final result lies in the state vector projection $|\psi> \rightarrow |a>$. We would therefore attempt to write

$$|a> = |\psi> \rightarrow |a> \tag{3}$$

This relation must not yet be taken as definitive. It is for the moment an intuitive suggestion. One can remark its self-referential structure, which brings us back to time. From a mathematical point of view it should not raise fundamental difficulties; an appropriate modification of Hilbert spaces in the framework of Combinatory Logic or of hypersets should be workable. As a self-referential "equation" in $|a>$ it has for a solution the limit of the infinite series $|a_n> = |\psi> \rightarrow |a_{n-1}>$; we recover the series of infinite observers encountered above. The Combinatory Logic provides another solution to equation (3) which avoids any infinite series, namely $|a> = YY$, where $Y = [x](|\psi> \rightarrow (xx))$[52].

[49] in *Discussions with Einstein on Epistemological Problems in Atomic Physics* p. 19

[50] in *The Elision*

[51] in *Include the Observer In the Wave Function ?*

[52] $[x]E(x)$ being the class of x's satisfying $E(x)$. See Fitch, *Elements of Combinatory Logic* p. 124

Let us point out that in this model there is no need to invoke a wave function of the environment or of the universe. The idea of self-reference explicitly introduced here was neared by D. Albert[53] but without formalization.

We can briefly compare this conception to the Everett's view of the relative state theory. His multi-universe conception, where there is never a state vector reduction, does not account for the empirical fact that among the multiple universes there exists always one which is actual. There is a clear analogy with time: in the same way that the description of time by the real line $\mathbf{R}$ does not explain the actualization of the present instant, the many-world interpretation does not explain why one of them is privileged and how its actualization takes place. According to view of the semantic state vector reduction, the choice of one among many worlds is a spontaneous, impersonal, semantic act of attribution.

5.2 An experimental prediction

Let us go back to time. Like any *significans*, the conceptual *significans* produced by the quantum measurement act is homogeneous to its own production. As such it spreads out over a period ΔT which we have seen to be about 0.1 sec. Thus the semantic wave packet reduction cannot, contrary to the usual statement, be instantaneous, it must take some time. More exactly there is a dead time ΔT after each wave packet reduction, because the latter occurs in another time, the transcendental time of the *significans* production process: there cannot be a new measurement before that dead time is over. In other words, in a given period of say 10 sec. there cannot be more than 10sec/0.1sec = 100 wave packet reductions. This statement constitutes a prediction which may be verified experimentally. Such a verification will probably not be made directly be "monitoring" the wave function in the course of its collapse because during the latter the transitional time is suspended. It is preferable to find some indirect demonstration *ad absurdum* in a way similar to the Bell's demonstration that the assumption of hidden variables leads to a contradiction with standard quantum predictions. We therefore exclude explicitly any theory where two successive effective collapses[54] are separated by less than ΔT.

This conception is a challenge which should encourage those who do not share the present view to imagine experiments demonstrating the existence of two collapses separated by an interval shorter than ΔT. The first idea coming into a physicist's mind would be to propose an experiment where say 1,000 successive quantum measurements are made and recorded on a given system in say 1 sec, and then to unroll these records so that an observer can verify that they did really take place. But from the strict point of view of the standard

[53] in *Quantum Mechanics of Self-Measurement*

[54] Excluding projectors onto intermediate states of the type $\Sigma|a><a|$ used in scattering amplitudes, since they are associated with effectively observed states.

quantum theory, it is precisely this unrolling which would, afterward, create the successive wave packet collapses. And these collapses, made in the semantic universe, would be separated from each other by an interval of ΔT. If this prediction were infirmed, i.e. if a way to make effective observations separated by less than 0.1 sec would be found, it would finally lead to a contradiction with the Copenhaguen interpretation or with the statement that the value of the fundamental constant ΔT is 0.1 sec. Whatever the result would be, it would constitute a useful step in the comprehension of time and of quantum mechanics.

In addition to this prediction, the theory of the semantic wave packet reduction explains three things in a natural way, without further assumptions:

- the irreversibility of the quantum measurement. Indeed, the time in which it takes place is not the constructed chronological time but the transitional time of the irreversible production of "now". The decoherence theory of Zurek *et al.* has its own explanation for irreversibility. But this explanation is subject to the same criticism as for the so called demonstrations of the H-theorem which in fact make an implicit use of time asymmetry.

- the non-covariant character of the wave packet reduction, which is not explained by the decoherence theory. The non-covariance is due, in a way similar to the non-covariance of the now explained in section 4, to the existence of a privileged reference frame: the frame of language in which the wave packet reduction takes place.

- it gives an answer to the *question of the concept of observable* formulated at the beginning of section 5.1. Indeed an observable is a semantic unit, or *semantem*, completely heterogeneous to the quantum level of wave functions; it is therefore natural that the description of the system by $|\psi>$ is not sufficient.

To conclude this section, the semantic model for the quantum measurement is not the only one conceivable, but it offers an occasion to understand another question, the Mind/Body problem which exists anyway. It is now time to say something more about it.

6 Psychical time and the Mind/Body link

If a *significans* is co-extensive to its own production, giving rise to a new instant, we must not forgive that it always has a material basis where it takes its source[55]. It establishes a link between Body and Mind. This is also the point of view of the freudian metapsychology which rests on the notion of drive. It is

[55]This is true even in Quantum Mechanics, although it somehow inflects the problematic: it is the measurement which attributes the predicate $G = x$ to the system, but it does not create the system itself, the latter pre-exists. In this sense the theory of the semantic wave packet reduction is not an idealism but a "semantic realism".

"the psychical representative of somatic excitations"[56]. This formulation has the disadvantage to let presuppose a psyche independant from the Body which "adresses" stimuli to it. To understand this operation of representation, let us make use of the remark made in section 2.1 about the kantian *schematism*. It was suggested[57] that the structure of the *scheme* is of the kind $C = S \to C$. In the same way it seems to me preferable to conceive the psychism as constituted by the stimuli, different but *not detachable* from their somatic sources, since they are, as said by Freud, their representatives; representatives which would at the same time be the result of the process of representation. The mind would be constitued by elements ψ which would at the same time be the destination of the representation of their somatic source S and the process of representation itself:

$$\psi = S \to \psi \tag{4}$$

In approximate linguistic terms, this would be similar to put the slash / of the relationship significans/signified into the *signifians* itself.

The representation inbedded in the concept of drive is a *movement of representation*. Like the *significans*, it is homogeneous to this movement and develops in a transitional instant of the transcendental time which it contributes to create. This entanglement of drive and temporality is also inherent to the freudian conception of pleasure: the pleasure is a decrease of a tension. It is not just the static difference between a higher and a lower state of tension, it is related to the *course* of its decrease. This lowering takes place in the course of time; not of the chronological time of physics, but of the transcendental time of the psychical representation of the desexcitation[58]. Thus, because where there is self-reference there is temporality, the latter is not only sharing its logical structure, it is also at the heart of the Mind/Body relation, so that one can say that temporality *is* this relation.

One can see the emergence of a self-referential model symolized by the expression $\psi = S \to \psi$. Seen from the point of view of non-stratification defined in section 2.3, this model is able to make a clear articulation between object and subject. A given term $\mathbf{S}$ is in the position of a subject when there is a non-stratified relation of the type $\mathbf{S} = R(\mathbf{S}, \mathbf{O})$ to a term $\mathbf{O}$, giving to the stratified term $\mathbf{O}$ the status of an object. Thus the characteristic of a subject is to lie in its proper relation to an object. The ancient oppositions, mind/matter, real/transcendent, which are oppositions of substances are now replaced by the structural opposition stratified/non-stratified. In the presence of a given external reality one can either make an experiment like in physics whose description is stratified, or have transference-like relations with it, having a non-stratified structure. As for the Mind, it is not in a layer independent from the Body, since it *is* its link to the Body, but at the same time detached from it. It is "semi-detached", between full detachment from the Body and

[56] in Freud: *The Unconscious*

[57] See footnote 12

[58] See J. Schneider: *Irreversibility, temporality and drive*

full identification with it. This "in-between"[59] is similar to the *one = two* of proto-arithmetic. To conclude these considerations, this conception of the Mind/Body relation is not a *monism*, nor a *dualism*, it is a *mono-dualism*.

The series of formulae of the type $a = (a, b)$ considered up to here are an illustration of a *restricted* self-reference. There is a *generalized* self-reference defined for a series of relations A, B, C etc by $a = A(a, b, c..)$, $b = B(a, b, c..)$, $c = C(a, b, c..)$, etc. It allows to construct, at least formally, a non-linear, multi-dimensional and "elastic" time, with temporal "bags" and reversals. This can be illustrated by a few graphical examples:

.

and

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or

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One can of course complexify at will such configurations. In each of them, each term x is at the same time a transition $y \to z$ and the starting or end point, eventually "anticipated" or "differed" of a transition. This two-fold nature is the characteristic of temporality; that is why these terms can be considered as instants. This kind of non-linear temporality offers a clear framework for the understanding of some aspects of psychical time. I can just mention, as a preliminary indication, the possibility[60] of interpretating, with the help of this non-linear time meta-psychological notions like differed action and the timelessness of the unconscious.

[59] For futher developments see *The self-referential structure of temporality* and *The logic of self-difference*

[60] Which will be developed elsewhere

7 Conclusion

To conclude I will underline the main guiding lines of this study. The analyzis of the "now" shows that it escapes physics and that it necessarily involves the dimension of meaning, together with its necessary underlying transcendence which, alone, allows the access to this now. It reveals the non-stratified structure of this transcendence and it implies the existence of a quantum of time ΔT to which we can provisionaly attribute a value of approximately 0.1 sec. The cause of the irreversibility of time would then lie outside standard notions such like entropy increase, T-violation of the K^o decay or expansion of the universe; time would be irreversible because of the irreversibility of the semantic production process of the now. As for the quantum ΔT, its existence leads to a non-covariance of the now which rehabilitates the views on duration of philosophers like Bergson. In the frame of a model of semantic reduction the wave packet in quantum mechanics, whose transcendental dimension is unavoidably imposed by the transitionality of time, the discretization of time leads to a specific assumption about the quantum measurement: the wave packet collapse is not instantaneous, it implies a dead time ΔT before the next collapse. The self-referential structure of temporality can be extended by the use of a generalized self-reference, leading to a non-linear time which can help to understand meta-psychological notions such as the timelessness of the unconscious. Finally one can, thanks to the temporal aspects of drive and pleasure, which are the border between mind and body, claim that inversely their link *is* temporality itself.

If in the course of this study we have been led to simultaneously explore physics, philosophy and meta-psychology, it is because it belongs to the nature of time to lie at their crossroads.

There are still several questions opened by this study and deserving further investigations:

- is there a sort of "infra-meaning" associated with physical phenomena much shorter than a tenth of a second?
- why has the quantum ΔT a value of about a tenth of a second? Is it possible to derive this value from some fundamental principles or must we accomodate ourselves to this arbitrariness?
- are there bifurcations of time as it would be formally possible, and otherwise why not?
- why is meaning homogeneous to its own production and not to its own disparition as would be permitted by the expression $a = b \rightarrow a$?
- is there an experimental evidence for a dead time of about 0.1 sec after a wave packet collapse?
- is it possible to experience a multi-dimensional non linear sort of time, allowed by generalized self-reference?

The task is now to find in the Reality answers to these questions.

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