Jules Henri Poincaré
(1853-1912)

SOME BASIC QUERIES

REVISED AND ABBREVIATED VERSION 2022 OF CHAPTER 8: 'FUNDAMENTAL QUESTIONS', IN MY "NON-STANDARD RELATIVITY", 2022.10.18 [4].

SUMMARY

In this chapter we shall allow ourselves
to consider the basic questions of physics
which are those bordering on metaphysics

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What is Truth?
Is the World Real?
Is the World just One?
Is the Universe Infinite?
Does the Universe Expand?
Is Nature Governed by Laws?
Are Occurrences Predestined?
Is Gravitation Instantaneous?
Is Time Causally Dependent?
Does Time Involve Change?
Is Simultaneity Universal?
Is the World Contingent?
Is Nature Timeless?
What is Time?

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Q1. WHAT IS TRUTH?

The question of truth is one of the great problems of philosophy. There are three different views of how truth is established, viz., a) by *coherence*, b) by *correspondence*, c) by *consensus*. All views are relevant as regards *scientific truth*: a) scientific theories *must be internally consistent*, b) they *must correspond to empirical facts*, c) they *must be accepted by a community of professional experts*. However, it should be noticed that: a) internal consistency is not a guarantee that a theory is founded on sound premisses, b) incompatible theories may explain the same facts, c) whole communities can be mislead. All three provisos are particularly pertinent with respect to Einsteinian relativity.

The concept of *meaning* appears to be far more comprehensive than that of *truth*. To construct a theory of meaning from a theory of truth is therefore devoid of meaning. Verbal expressions carrying truth-value we call *statements*, or *propositions*. Ordinarily we reckon two truth-values: '*true*' (1), and '*false*' (0). With a Boolean algebra operating on the system of binary numbers we can compute the truth-value of a complex statement from those of its constituents. With (1) for '*on*' and (0) for *'off'*, we can implement logical gates electronically to the construction of an universal computer (*Turing machine*).

Using 'p', 'q', 'r' as symbols representing simple (un-analyzed) propositions, and following Tarski, we can define *the truth of 'p'* thus: "The proposition 'p' is true *iff* (i.e.: if, and only if) p". The *calculus of propositions* can now be constructed on the basis of various axioms, with rules of derivation and definitions of *wff*'s (well formed formulae). A simple and beautiful axiomatics is that of Lukasiewicz (1924): it is based on 3 axioms:
L.1 $(\neg p \Rightarrow p) \Rightarrow p$, read: "If not-$p$ implies p, then p" (if 'p' is undeniable, then 'p' is true);
L.2 $p \Rightarrow (\neg p \Rightarrow q)$, read: "If p, then not-p implies q" (contradiction involves absurdity);
L.3 $(p \Rightarrow q) \Rightarrow ((q \Rightarrow r) \Rightarrow (p \Rightarrow r))$: "If: if p then q, then: if q then r, then, if p then r" (transfer of truth-value by the classical syllogism).

If we want to consider the internal structure of propositions instead of analyzing their syntax, we must go to the predicate calculus, also called the theory of quantification. The *calculus of predicates* is a modern development of the subject-predicate calculus of Aristotle, which was found to be problematic on account of its metaphysical implications: the subject was seen to imply the need of referring to a thing, entity, or substance; so the elimination of the subject, by way of reducing it to a description in terms of predicates, was meant to liberate logic from the fetters of antique ontology.

For the same reason it is problematic to base a semantical theory on the premiss that symbols get their meaning by referring to things or objects, whatever their properties. More reasonable is it to assume that objects and their properties are constituted by way of the actions we perform on them as well as the operational procedures we expose them to. The predicate calculus construct its propositions by quantifying over variables standing for unknown objects, whereof we then affirm or deny predicates representing properties. The quantifiers are operators, universal or particular, giving rise to universal or particular statements, resp. Natural laws are stated by universal propositions, boundary conditions by particular ones. A problem in today's science is if this cleft can be bridged.

Q2. IS THE WORLD REAL?

What do we mean by 'the world'? Is it the *sum total* of all what we experience? Who are 'we', in the plural? How can we be sure that the world I experience is the same as the world you experience? Does anything at all remain invariant if the perspective is shifted from you to me or from me to you? It seems so easy when we talk with people we know well and maybe are very fond of, but if the identity of human persons surrounding us is put into jeopardy, we are in trouble. As long as the communication between persons is unperturbed, we feel confident; but feeling is a feeble foundation of science.

We assume that the *structure* of the real world is *invariant*, common to different people, and the task of natural science is precisely to disclose this structure, describing it by a mapping. Even if we do not agree about details in the scientific mapping of nature, we are convinced that, behind our sense impressions, there is a "real world" that causes what we perceive. This is what is meant by *scientific realism*: the feeling of confidence, the belief in "something real" behind all our sense appearances.

This "reality" Kant termed "das Ding an sich", in contrast to "die Dinge für uns". Did Kant leave us with any hope that science finally succeeds in finding "the real thing"? Not at all! Not the faintest hope! The hunt is like chasing a *fata morgana* in a desert. The same view is stated by Rowlands [2007] p.60: "There is no such thing as 'reality' "! So, what can we hope for? Well, *maybe we are able to map the structure of phenomena in the world as it appears to us, indeed, as it must necessarily appear*.

This is what Kant would tell us: whereas it is hopeless to obtain any knowledge of the universe as-it-is-in-itself, we can at least hope to get true knowledge of the universe as-it-appears-to-us; the reason is that the universe of appearances is not independent of the way we comprehend it. Just as our *perceptions* are necessarily encompassed by the framework of *time* and *space*, so our *conceptions* of what is, or happens, necessarily conform to *the way we think*, indeed *must* think. This Kantian stance may be interpreted as stating a primordial version of the *Anthropic Principle:* "Der Verstand schöpft seine Gesetze nicht aus der Natur, sondern schreibt sie dieser vor"; and: "So ist der Verstand der Ursprung der allgemeinen Ordnung der Natur, indem er alle Erscheinungen unter seine eigne Gesetze fasst", [1783 §§36-38]. A similar position was held much later by Eddington: "My conclusion is that not only the laws of nature but the constants of nature can be deduced from epistemological considerations." [1939 ch.4].

For my own part, *I prefer to retain truth as a regulative idea* in the sense of Kant, meaning that we should strive for true knowledge of the real universe. But this position appears to face *insuperable difficulties*, if considering the finite speed with which causal effects are propagated. The observable universe then presents itself to us as a sphere of concentric shells whose age is increasing outwards with their distance from the center. If we look outwards, we look into the past, seeing the world in a temporal perspective. But how do we pass from ***world-view***, the world as it appears to us, to ***world-map***, the world as it is in itself, *now*, if simultaneity is spurned referring to the finite speed of light? Without this distinction, the idea of a *scientific cosmology* seems pointless.

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Q3. IS THE WORLD JUST ONE?

Apparently the universe could have been many, and that in many different ways. Thus it has been found needed to buttress the "Big Bang" theory by *ad hoc* hypotheses.

At first, the BB was hailed for supporting the cosmological principle. Then it was realized that the resulting isotropy and homogeneity was too strong, so the observation of small ripples in the CMBR was saluted for giving rise to the inhomogeneities necessary for the galaxies to form. Next it was admitted that these inhomogeneities might grow up to prevent the uniform distribution of matter in space, so some more mixing was needed. Here the idea of "inflation" came to the rescue. Finally, we got the idea of a "multiverse". This has been seriously compared to a "boiling porridge" by Krauss [2012] p.128.

The many-worlds hypothesis of Everett and Wheeler likewise holds that our world is not a universe in the proper sense, but rather a "multiverse" consisting of an infinity of "parallel universes" co-existing side by side in a "super-spacetime" without any real time. This "multiverse" is imagined to be *branching* at every instant when an event occurs, the hope being to retain a *unitary description* of the "multiverse" represented by a quantum wave-function Ψ, without admitting a *collapse* of Ψ whenever an observation is made. In this way they claim to have solved the problem of the "wave-function collapse".

Something similar is found in *modern tempo-modal logic* which has adopted the Leibnizian concept of "possible worlds" in order to make sense of its semantic models. Just like the above mentioned many-worlds interpretation of quantum mechanics, tempo-modal logic assumes a *branching of possibilities towards the future*, the *now* being the earliest branching point, and past moments connoting possibilities grasped or wasted. Here the "multiverse", making up an infinite ensemble of "possible worlds", is visualized as a "tree of life", with "branches" pointing towards the future, its "trunk" being the actual course of past events, its "twigs" being the possible outcomes of our present actions or accidental events, and each "possible world" being a linear course of future events going out from the present moment. Such "possible worlds" cannot be "parallel", but may be imagined as "bundles" of "world lines", forking from the "trunk" at each instant.

Now a hot question arises: Which status should be ascribed to the "multiverse", defined as a total ensemble of "possible worlds", or "temporal world lines"? Is it *reality*, or just *fiction*? Notice here that the many worlds interpretation of quantum mechanics claims a wave function Ψ to determine the "multiverse" by comprising all possible events. The point of the hypothesis is that Ψ, albeit unknown, is taken to describe "everything". Thus it seems possible that we, "in principle", are in possession of a unitary description of the "multiverse" enabling us to comprise all possible futures in a single unified theory. Is it not legitimate to say that the hypothetical wave function Ψ is "virtually real"?

The same question turns up in the "possible worlds" semantics of temporal logic: are "possible worlds" not "virtually real"? Here we are witnesses to a stark disagreement between *possibilists*, who are apt to answer 'yes', and *actualists*, who are apt to say 'no'. But if "Ockham's razor", the principle: *entia non sunt multiplicanda praeter necessitatem*, is accepted, there can be no doubt about the answer: ***Only One World Is Real!***

Q4. IS THE UNIVERSE INFINITE?

Cosmologists normally eschew *infinity*, but the idea was seized upon in order to make sense of the *Anthropic Principle*. According to this piece of wisdom, the universe is as it is because we are its inhabitants, the point being that, if it were a little different from what it is, we would not be alive. Since it is unbearable to most scientists that the universe was designed by a divine creator to the purpose of being inhabitable to conscious beings, it seems that *infinite space* is needed for a *cosmic Darwinian evolution* to occur.

So the saying goes that the "multiverse", by a rapid expansion after the "big bang", was blown up to contain "bubbles", each "bubble" being an independent mini-universe ruled by its own laws, with natural constants varying by chance, and "mostly" isotropical. With an infinity of "baby-universes" bubbling and babbling in infinite "super-spacetime", it would be flatly incredible, Smolin opines, if not a few of them were similar to our own, and one of them *is therefore, by lucky chance,* just that particular universe we inhabit. How this confusing variety of "laws" and "constants" can be compatible with an *unitary* all-embracing quantum wave function Ψ, it is probably better to forget all about.

Accepting *the unison verdict of Plato, Cusanus, Leibniz & Kant: the world is one,* we can begin to discuss seriously: are there any other ways our universe can be infinite? Already Newton confronted the question of gravitating bodies in infinite space and came to the result that an "island" of stars situated at rest in infinite space would be unstable; he noticed that to put an infinity of stars at permanent rest in infinite space would require a balance of forces far more precise (infinitely more) than to balance a needle on its tip. Einstein wrestled with the same quandary and proposed his model of a static, unbounded universe in a closed, spherical space - but, for him, the "needle" didn't balance either.

Harrison [1981] has reviewed all world models compatible with General Relativity: $a)$ some in spherical space, an initial phase of expansion leading forth to a final phase of contraction, $b)$ some in flat space, an initial expansion decelerating towards zero due to the brake of gravitation, and $c)$ some in hyperbolic space, the expansion being accelerated towards the light speed limit. Common to all models is that they conform to the metric of Friedmann, their seeming validity *proving GR to be a technique* and not a genuine theory. Against spatially infinite world-models, Harrison misinterprets an argument of Poincaré, proving that any finite number of atoms will recur to their original configuration in space, if rearranged an infinite number of times; this argument is only valid for certain types of dynamical systems. I share Harrison's disgust of Nietzsche's notion of an "eternal return", but his own objection to the notion of an infinite universe cannot be taken seriously.

A unique model of an infinite universe, expanding uniformly at the speed of light from a so-called *transcendent point-event* ("white singularity"), was proposed by Milne. This model is infinite in the sense that it is at its present stage of development populated by an infinity of stars, but is nevertheless described in two seemingly incompatible ways: as an expanding sphere according to the t,r scale, and as eternally at rest in infinite space according to the τ,ρ scale. My own favourite world-models - I offer three closely related modifications of the KR-model of Milne - are presented in this book, ch.s 16 &17).

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Q5. DOES THE UNIVERSE EXPAND?

Many physicists and cosmologists cannot accept the idea of an expanding universe. Most members of ***ACG*** (the *Alternative Cosmology Group*, *www.cosmology.info*) and ***NPA*** (the *Natural Philosophy Alliance*, *www.worldnpa.org*) univocally reject the notion. The same holds for other of my allies in the fight against Einsteinian dogma and myth. One may nourish a suspicion that their attitude is simply due to shortage of imagination.

Below, I shall marshal some important arguments in favour of a dynamic cosmos. The observations of Slipher and of Hubble that light from distant galaxies is subject to a shift of spectral lines towards the red end of the spectrum and increasing with distance, strangely did not lead Einstein to consider the possibility that the redshift might be due to a universal motion of scattering, or expansion.

The first to suggest a proportionality between distance and velocity for distant galaxies ("Hubble's law") was the cosmologist Robertson in 1928; but as early as in 1917, the astronomer de Sitter predicted a systematic displacement of spectral lines towards red. His own new static world model differed from that of Einstein due to a strange property: if free particles are sprinkled into the model's otherwise empty space, they will spread. So de Sitter had "motion without matter" where Einstein had "matter without motion".

An expansion *of* space itself is very different from a dispersion of matter *in* space. The notion of an expansion *of* space implies a steady increase of inter-galactic distances according to a universal expansion function that has a cosmic time as its free parameter. A dispersion of matter *in* space may also involve a steady increase of distances between galaxies without the spatial metric being affected; so is the case with my own models.

With respect to the Milne model of KR the whole issue is even more complicated, because Milne operated with two possible time-scales, t-time and τ-time, τ-time being a logarithmic function of t-time. Here t-time is our usual time-scale, its unit being defined by taking the sizes of atoms as being invariant. The inter-galactic distances then increase according to Hubbles' law, $r \propto t$. But the choice of a time-scale is purely conventional. Thus, if one prefers the τ-scale instead, one is free to assume that all galaxies are at rest, and that the sizes of their constituent atoms are shrinking as time is passing by!

Both time-scales give rise to an observable shift of spectral lines toward the red, but the explanation is different in the two cases. As calculated in the t-scale, the effect is an ordinary Doppler-effect, due to the scattering of sources. In the Milne-model of KR, this is equivalent to an expansion with light speed c of a world-space of infinite contents, here a perfect sphere with finite radius $R_u = ct$, into a fictitious, empty, and flat, 3-space. When calculated in the τ-scale, the observed red-shift is explained as being due to light being "tired", due to a secular reduction of Planck's "constant" (: variable in the τ-scale). Both red-shifts solve the question of the dark sky at night ("Cheseux/Olbers-paradox").

To say that Milne's world expands into pre-existing space might pose a problem. But, like Poincaré, Mercier and Rowlands, he might reply: Space is not anything real!

Eddington once remarked: "The theory of the expanding universe is equivalent to the theory of the shrinking atom!" - My dear reader: You are free to feel confused! -

Q6. IS NATURE GOVERNED BY LAWS?

The notion of "physical laws", or "laws of nature", sound archaic to modern ears, derived as it is from such sources as Anaximander: "Whence the origin of things, thence also their demise, according to necessity: for they pay penalty to each other, atoning their trespasses, in accordance with the order of time.", and Herakleitos: "The Sun will not trespass its measure, or it will be prosecuted by the servants of justice / revenge".

In its modern form, of course, it is due to Newton who claimed to have deduced from experience these *principles of motion*: 1) the law of *inertia*, 2) the law of forced *acceleration*, and: 3) the law of *action and reaction*. Of these, the two first laws are contained in: $\boldsymbol{F} = d\boldsymbol{p}/dt = d(m\boldsymbol{v})/dt = \boldsymbol{v}(dm/dt)+m(d\boldsymbol{v}/dt) = m\boldsymbol{a}$, $\boldsymbol{F} = 0$ giving 1), and $\boldsymbol{F} \neq 0$ giving 2). Finally, we have: 4) the law of *universal gravitation* with $\boldsymbol{a} = GM/\boldsymbol{r}^2$, as the gravitational acceleration. But Newton cautiously renounced on *explaining* gravity, saying he was unable to do so, therefore satisfying himself with *describing* it.

The *Great Book of Nature* is written in the language of mathematics, Galileo said, and the task of science is to discover the true causes (*verae causae*) behind phenomena; but according to his teacher Plato (Galileo often referred to Plato) this is too much to hope. for "regarding natural phenomena, we must content ourselves with the probable". Descartes, his contemporary, proposed the first law of conservation, that of momentum, and intimated that, if God had created only the matter of the universe together with all its laws, the result after a process of evolution would be precisely the world as we know it. A similar view of the universe as a *clockwork mechanism* was suggested by Leibniz who replaced the conservation of momentum with that of energy, but warned against pushing the idea of mechanical causality too far, since it only scratches the surface of reality.

In public opinion, it was Hume who, by his criticism of the concept of causality, defined as necessary connection, showed Newton's system to be a castle built in the air. The scandal of philosophy, unable to disclose a solid basis for an exact science that had provided us with such deep insights about the working of nature, was a challenge to Kant; his solution to the puzzle was placing the necessity in human reason, instead of in nature. His contemporary Laplace, relying on his own mechanistic explanation of the universe, dismissed the traditional hypothesis of a divine Creator. However, thermodynamics raised new problems regarding its second law, which were not solvable by statistical mechanics, and some scientists urged for a phenomenological interpretation of that branch of physics. The final break with determinism occurred with quantum mechanics which supplemented a strictly deterministic wave equation by a purely statistical interpretation. One can say that quantum theory thereby reconciled the opposite views of Plato and Galileo.

It is normally held that laws of nature are expressible by universal propositions, preferably mathematical equations relating to empirically defined objects or properties. The great question is whether such laws exist. Maybe chance is fundamental, so that all apparent laws are nothing but statistical regularities? This view is corroborated by Milne: following his KR, the laws of gravity and electrodynamics are *statistical habits of nature induced by cosmic asymmetries* - cf. van Fraassen [1989].

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Q7. ARE OCCURRENCES PREDESTINED?

Even if the basic laws of quantum mechanics allow only probabilistic predictions, there are arguments for determinism, or fatalism, of a very different character.

According to the famous *master argument* of the antique thinker Diodoros Kronos this trilemma is inconsistent: 1) Something impossible does not follow from the possible. 2) If something is or was the case, it will necessarily have been the case. 3) Something is possible that is not the case and will never be the case. Taking 1) & 2) to be indispensable, he claimed to have shown the falsity of 3). Therefore, if something is possible, it either is the case or it will be the case in the future. With plausible definitions of 1) and 2), it can be shown that he was right, granted that not only the past, but also the future, is linear; cf. Øhrstrøm & al. [1995]. Thus it follows that the master argument can be circumvented if time is conceived like a "tree" with infinitely branching future possibilities.

Another example is the *lazy argument*, which was often used for comfort by, e.g., the London citizens under the blitz in WW2: "Whatever I do, it is all written in the stars: if an accident hits me it is written in the stars; if it does not hit me it is written in the stars. So it does not matter what I do". This argument was effectively refuted by Aristotle:

"If a man says that something will be, and another that it will not be, it is necessary that one of them must be telling the truth; that is, if every assertion is either true or false but not both at the same time .. On this assumption, nothing exists or happens by chance .. but everything will happen of necessity .. Thus it is necessary that everything which is going to happen must happen .. If this holds, there is no need for us to reflect on or hope for anything .. But these consequences are impossible: we know that future occurrences do stem from our choices and actions .. Therefore, what I think is something like this: Necessarily, either there will be or there will not be a seabattle tomorrow. But neither (does it follow) that, necessarily, there will be a seabattle tomorrow, nor (does it follow) that, necessarily, there will not be a seabattle tomorrow." - *De Interpretatione ix*.

The argument, demonstrating the fallacy of distributing the necessity operator over a disjunction, can be supplemented with the following modern interpretation of quantum theoretical probability in terms of a tempo-modal notion of future-directed possibility:

"Probabilities are intimately related to the future. They are a form of what might be called 'the presentness of the future'. The future is present in the form of possibility. Statements regarding possibility and probability are neither 'subjective' .. nor 'objective' .. but rather 'objective in a subject related way', that is, they can only be formulated on the basis of a certain knowledge, but they are then testable by anybody who is in possession of that knowledge. In a 'monistic' philosophy of both mind and matter .. this kind of 'subjectivity' is a characteristic of all sorts of being. The reduction of the wave packet is nothing but a gain of information based on new knowledge. The apparition of paradox has only emerged because the meaning of the Ψ-function as being 'subject related in an objective way' was not properly acknowledged. What is then left to ponder is only a quantum theoretical description of knowledge itself." (my translation, MTW).

C.F. von Weizsäcker [1992] p.890.

Q8. IS GRAVITATION INSTANTANEOUS?

According to Rowlands the speed of the force (not the waves) of gravity is infinite: "The Sun's gravity emanates from its instantaneous .. position, as opposed to the direction from which its light seems to come ... No relativist has as yet, to my knowledge, devised a theory to explain how it can be that the direction of the Sun's gravitational force and the direction of photons arriving from the Sun are not parallel." - quoted from [2007] p.448, and referring to some startling new evidence presented by T. van Flandern.

This contradicts the premisses of General Relativity (GR). In Rowland's opinion: GR is not a theory of gravity at all. It provides no mechanism for the gravitational force. Neither does it replace the Newtonian theory; rather it makes use of it, requiring that the weak field limit of the gravitational potential, put in by hand, be the Newtonian value. Its field equations, describing the spacetime curvature, have no relation to gravity at all. The only bond between curvature and gravitation is tied when the classical potential is inserted by hand into the simplified equation for the radial field around a point-source, the so-called Schwarzschild-solution; confer his [2007] p.452.

Rowlands urges the problems caused by the fact that GR is nonlinear, ibid., p.478: As such, it openly admits its own insufficience by producing unrenormalisable infinities. It ignores the fact that the solution by Schwarzschild, approved by Einstein, was linear. It is too difficult to handle for cosmology and black hole physics without simplifications. It does not give a description of gravity, even in principle, and modifying it is of no avail. It invites the possibility of a unified field theory, but as such it is just a hopeless failure. It destroys the basis of a series of important symmetries that would be natural without it. If taken seriously, it predicts the closure of a universe filled up with zero-point energy. Seen as first stage in an unending number of best-fit models, it excludes a unified theory. Contradicting a nonlocality supported by experiment, it also contradicts quantum theory. Finally, it fosters the perverse idea that high-brow math is needed at a basic level!

Following Rowlands, unless one believes in some extreme version of the anthropic principle, the laws of physics in a unified theory must be true in all places at all epochs, ibid.p.600. Except that Rowlands deliberately eschews cosmological models, his stance as just expressed is clearly in line with the ideas behind the models of continued creation presented in this book. Furthermore, his claim that the gravitational force is instantaneous agrees very well with the view of Milne that gravitation is a spontaneous consequence of local deviations from global symmetry: in a kinematic universe there is no gravitational attraction between fundamental particles, hence no brake on their dispersion.

But Rowlands attempts to derive inertia from gravity, following Mach's principle, whereas I consider it more natural to derive gravity from inertia, in opposition to Mach, but in agreement with Milne. The remaining question is if Milne's kinematic method is applicable to a physics based on something like Rowland's remark above; compare the so-called "perfect cosmological principle" of Gold & Bondi. However, it is clear that the stability of such a physics must be able to allow statistical variations of an enormous size, in order to be compatible with current astronomical observations.

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Q9. IS TIME CAUSALLY DEPENDENT?

There is a trend in modern philosophy of science to see causality, causal order, and causal connectivity, as more basic than time and temporal order. To discuss this attitude properly, we have to settle on a plausible definition of causality; but this is not that easy, as there is at least three very different theories of that concept: 1) the *probabilistic* theory, 2) the *counterfactual* theory, and 3) the theory of *covering law*.

Against all three theories it can be objected (assuming that they pretend to explain time in terms of causality) that they presuppose what they attempt to explain. As regards the *probabilistic* theory, it has to be stressed that it is hard to see how the concept of probability can be ascribed any sense concerning events that are already present or past. Regarding the *counterfactual* theory it must be noticed that the notion of a counterfactual course of events implies that past facts are now unpreventable and irrevocable combined with the speculative imagery of past-future events that are no longer possible but which might under other circumstances have been possible at an earlier stage of development. With regard to the *covering law* theory we should distinguish between laws of classical mechanics that are reversible and deterministic, giving no clue to the difference between earlier and later, and the laws of thermodynamics, where the second law is itself in need of a clue as to which of the two directions of time should be viewed as leading towards increase of entropy. The laws of quantum mechanics are indifferent to temporal order; however, a "wave function collapse" will always create an irreversible fact.

But there is still a theory of causality, based on the *mark method* of Reichenbach. In his [1958] p.136, he claimed to have a time independent definition of cause and effect, so that the relation of cause to effect can be used to define the relation of earlier to later. Starting with the temporal neutral concept of causal connection $C(E_1, E_2) \equiv C(E_2, E_1)$, he defined the causal order of the events E_1 & E_2 thus: if a small variation of E_1 to E_1^* is compatible with a small variation of E_2 to E_2^*, but not the other way round, then E_1 is cause and E_2 effect. This means that the combinations E_1E_2, $E_1^*E_2^*$, $E_1E_2^*$ may all occur, but never this one: $E_1^*E_2$. It seems that we have a fool-proof definition of the temporal order in terms of the causal one. But it is easy to produce a very simple counter-example. Drop a pea into a round bowl, vary the throw as much as you wish, let the pea roll forth and back a few times, the result is always the same: a pea in the center of the bowl!

The only reasonable option is to define causal order in terms of temporal order, and our best choice is to define it in terms of physical laws. The definition I prefer is this one: *take a well defined energetic system subject to laws determining its development in time; granted that the various stages of this proces display a clear and distinct temporal order,* we shall say that any earlier stage is *causally connected* to any later stage, the *earlier* one being the *cause* of the later one, and the *later* one being the *effect* of the earlier one. Furthermore, we have to distinguish *deterministic* laws from those that are *probabilistic* and, finally, we must discern conditions that are *necessary* from those that are *sufficient*. This is the *only precise definition of causality* that can be given; and, if *the world-course* is *a system of zero energy,* the definition presents it as *a chain of world-states*.

Q10. DOES TIME INVOLVE CHANGE?

Science aims to *describe* the present, to *predict* the future, and to *explain* the past. The difference between science and superstition depends on its way to perform this task. So science *presupposes the tripartition of time into past, present and future*; nevertheless, the distinction between *determined* (past-present) and *undetermined* (future) may suffice. This places the question of *tenses* in the focus of our attention. I will not hesitate to brand the view that tenses are fictitious as a particularly pernicious sort of superstition.

Another view, more plausible at a first glance, is that time is subordinate to change. Aristotle, e.g., defined time as "the number of motion with respect to before and after". To Aristotle, motion meant change, and he distinguished four different kinds of change: a) change of *substance*, b) change of *quality*, c) change of *quantity*, d) change of *locality*, going from essential motion to superficial motion. It is ironical that the origin of modern science was due to a change of attitude towards seeing spatial motion as the basic one; this explains why spatially extended objects were considered fundamental; but even more ironical is it that the majority of today's scientists without reflection accept Aristotle's view that "reality" is a question of "things" defined as objects with changing properties.

Modern logic has long ago accepted the fact that objects are conceptual constructs devoid of inherent substantiality, recognizing that only statements can have truth-value. Why do physicists, e.g., Einstein, Podolsky & Rosen, then still argue in behalf of a realism that is naïve by way of assuming the reality of objects ("quantal systems") that after being connected in the past by an event of interaction are no longer entangled, but independent? Why not accept that quantum theory has put an end to the old idea of objectivity?

The way out of this impasse is very simple. Don't ask what is! Ask what happens! What happens are *events* and events, present or past, are *facts*, whether perceived or not. Stricly, only statements, specific linguistic expressions, can be "bearers of truth-value"; this seems to involve consciousness, thus we are at the point where matter meets mind, and that is why the Copenhagen interpretation of quantum theory, claiming that physics does not care about *reality* but about our *knowledge* of reality, was felt so provocative.

Accepting, with von Weizsäcker, that: "the object, to which such a theory (abstract quantum theory) is related, is not a *thing*, but a *stream*", [1985, p.363], furthermore, that: "in the (concrete) quantum theory, the spatiality of objects is only a derived / secondary property" [ibid.p.391], and finally, that: "if the quantum theory is taken seriously .. then, stricly, there are no separate objects, but an (entangled) whole", [1992 p.329] - then it is natural to conceive of *reality as a temporal flow, or stream*, broken up by the tripartition of time into 1) *present events,* that are just now made actual, 2) *irreversible facts*, that are inevitably past, and 3) *future possibilities* that may or may not become realized.

From this we construe objects, and thus the change of temporal modalities is the primary form of change**.** Weizsäcker has axiomatized SR & QT by using temporal logic. The bare change of tense operators as applied to statements would in itself be vacuous if the statements were empty, so that nothing whatever were true. This might be the case if facts were not irreversible; but that, of course, is only a weird speculation.

Mogens True Wegener

Q11. IS SIMULTANEITY UNIVERSAL?

A.N. Prior, the founder of tense logic; his full text is reprinted in Wegener [1999]:

'Having happened' is not the kind of property that can attach to an event from one point of view but not from another. On the contrary, it's something like existing; in fact to ask what has happened is a way of asking what exists, and you can't have a thing existing from one point of view but not existing from another, although of course its existence may be known to one person or in one region, without being known to or in another. So it seems to me that there's a strong case for just digging our heels in here and saying that, relativity or no relativity, if I say I saw a certain flash before you, and you say you saw it first, one of us is just wrong .. To put (it) in another way .. the 'time' which enters into the so-called spacetime of relativity theory .. is just part of an artificial framework which the scientists have constructed to link together observed facts in the simplest way possible ... This sort of thing has happened before .. When the differential calculus was invented, its practitioners used to talk a mixture of excellent mathematics and philosophical nonsense, and at the time the nonsense was exposed for what it was by the philosopher Berkeley .. The mathematicians saw in the end that Berkeley was right .. when they became occupied with problems which they could solve only by being accurate on the points where Berkeley had shown them to be loose; then they stopped thinking of the things he had to say as just a reactionary bishop's niggling and began to say them themselves .. It may be that some day the mathematical physicists will want a sound logic of time and tenses; .. meanwhile the logician had best go ahead and construct it, and abide his time.

Text reprinted from Brown & Davies, eds.: *The Ghost in the Atom* [1987]:

Interviewer: *Bell's inequality, as I understand it, is rooted in two assumptions: the first is what we might call objective reality, the reality of the external world, independent of our observations; the second is locality, non-separability, no faster-than-light signalling. Aspect's experiment* (indicates that one has to choose. Which one would you stick to?)

John Bell: *It's a deep dilemma, and the solution of it will not be trivial. It will require a substantial change in the way we look at things. But .. the cheapest resolution is something like going back to relativity as it was before Einstein, when people like Lorentz and Poincaré thought that there was an aether - a preferred frame of reference.*

Text reprinted from C.F.v. Weizsäcker: *Aufbau der Physik* [1985] pp.52&313:

Ein systematischer Aufbau (der Physik) würde verlangen dass zuerst die vollständige Logik zeitlicher Aussagen entwickelt und auf sie dann erst die physikalischen Theorie gegründet wurde .. Die These dieses Buchs ist, dass eine Logik zeitlicher Aussagen fundamental selbst für die Begründung der klassischen Logik sein sollte; dass diese zeitliche Logik in den Ausdrucksweisen der Umgangssprache, vielleicht am deutlichsten in den indogermanischen Sprachen, schon implicite enthalten ist; dass die Quantenlogik eine spezielle Fassung diese zeitlichen Logik ist; und dass insofern die Quantentheorie nur der Anlass war, der uns zu dieser .. Reflexion veranlasst hat.

Q12. IS THE WORLD CONTINGENT?

For centuries it has been the aim of philosophers and physicists to invent a theory of the cosmos showing it as a self-explaining mechanism, the cause of its own existence. It being impossible to devise a *perpetuum mobile* from a particular energetic system, maybe one could construct the whole universe as such? Isn't the universe itself *causa sui*? Then the divine prerogatives could be transferred from God to his supposed creation: nature could be considered the only god, as Spinoza, Hawking, and Krauss would have it. The scientist who, in my view, has made the most promising attempt in this direction, is P. Rowlands [2007]; not knowing his stance to metaphysical issues precisely, I have no doubt that his ambition to construct a "TOE" (theory of everything) is very high.

Following Rowlands (p.2) "we cannot devise a unified theory simply by combining quantum mechanics and general relativity in a new mathematical superstructure", such attempts being doomed to fail because partial theories are not unified by combining them, but by deriving them from a common origin: *zero* must be the point of *departure* as well as that of *arrival*. Only *nil*, or *nothing*, split up into *duality*, is able to explain *everything*. From the point of view of physics (p.84f.), "the Dirac nilpotent equation would seem to be a perfect way of producing something from nothing", as it incorporates all groups of interest; the conservation laws implied by $(\boldsymbol{k}E + i\boldsymbol{i}\boldsymbol{p} + i\boldsymbol{j}m)(\boldsymbol{k}E + i\boldsymbol{i}\boldsymbol{p} + i\boldsymbol{j}m) = 0$, including mass-energy and 3 kinds of charge, fix the behaviour of all physical systems. Basing our mathematics not on the integers, but on a zero totality, we are able to produce "a mathematical structure avoiding the incompleteness indicated by Gödel's theorem".

Amplifying this (p.556f.), Rowlands proposes to start with *one symbol* representing 'nothing', and *two basic rules* (duals of one): α) *create*, a process adding new symbols, and β) *conserve*, a process examining the adding of any new symbol on those existing, to ensure their zero sum. He further points out that *a nilpotent universal computational rewrite system (NUCRS),* used on an infinite alphabet defining the semantics of quantum mechanics in terms of a universal grammar, *may suffice to determine the structure of cosmos, the genetic code, the human brain, and human language.* The *NUCRS* may thus enable us to establish an *Evolutionary Anthropic Semantic Principle* describing the rules by which a sentient being is able to comprehend *Nature's Own Rules*.

I highly admire the daringly intrepid and deeply original construction of Rowlands; but how do we judge his claim that *NUCRS* avoids the incompleteness theorem of Gödel? The prospect of *a closed physical system complete with syntax and semantics, containing a unified description and explanation of both mind and matter*, is not very bright:

"We may note here that it *is* possible to construct a calculus rich enough in its symbolism for the statement within itself of its .. own *syntax* .. (but *not* of) its *semantics* .. It cannot be said within any system .. that the system is *complete* .. i.e., its unproven theses and rules suffice to prove all theses .. true for all interpretations of their variables." Prior [1962] p.70. The proof, cf. this ch. ref.10, is immediately applicable to *NUCRS*. -

Even if Rowlands succeeded in mapping all invariant laws and pure numbers of all possible worlds, the abyss between possibility and factuality would not be bridged!

Mogens True Wegener

Q13. IS NATURE TIMELESS?

In a special issue of *Scientific American* dedicated to ***Time*** [287 no.3 sept.2002] a notable sceptic makes fun of the fact that smart people often believe weird things. The innocent reader may be surprised to learn that this ironical remark, targeting at phenomena such as astrology, clairvoyance, magnetotherapy, and ufology, may also be applied to some allegedly scientific views promoted in that issue.

Scientific American is generally acknowledged to be a quite serious magazine and Paul Davies, a scientist of high repute, is regarded as one of the more reliable mediators of modern physics. Nevertheless he makes himself a spokesman of the opinion that, from the point of view of science, the idea of temporal flux is nothing but illusion, attempting to underpin this view by appealing to the special theory of relativity.

In contrast to physics, which is neither capable of explaining what it means that "time is passing" nor qualified to ascribe a direction to "the arrow of time", there is a large number of other sciences which not merely presuppose the passage of time, hence also its direction, but which even prosper by describing it. At the same time it is equally obvious that these historical sciences would lack all scientific legitimacy if the metaphor of *time-in-flow* could be shown to be meaningless or indefensible.

Turning our eyes towards a science like biology it seems evident that something as basic as the doctrine of natural evolution must appear devoid of any rational meaning, if the concept of time's passage cannot be accorded any scientific status. That it cannot is argued by J. Barbour's *End of Time* [1999], which I take to be the final apotheosis of Einstein's scientific program: to reduce everything in physics to "spacelike concepts". It is paradoxical and very problematic that the recent results of science force us to choose between physics and biology. But a similar conflict can be found *within* physics!

According to the unanimous verdict of modern cosmology and biology, everything observed in the world today is nothing but the prolonged effects of an evolution initiated by the creation of the universe in a that happened about 13.7 billion years ago. However, some physicists want to persuade us not only that the passage of time is an illusion, but that the notion of time lacks all scientific foundation! So the urgent question of today is: How can we trust a science that not only denies what everyone can observe with his own senses from instant to instant, but which also is in blatant conflict with itself?

Q14. WHAT IS TIME?

Tense logic, or *the logic of change*, is relevant when we study statements in their natural context which is a context of temporal change. What we perceive is reality-in-change and, just as reality itself is emerging and expiring, our language, in order to reflect this, must represent it by the successive origin and closure of the truth of its assertions. The stuff of tense logic consists mainly of temporally indefinite statements, the definite statements being those which are omnitemporal, those which mark an absolute beginning or an absolute ceasing, and those that are unique in the sense that they are true *now*, but neither true in the past, nor in the future. The verb always refers to the present.

In the chapters 10-12 I have sketched a new system, $\mathcal{W}$, of tense logic which is *indeterministic* not only in the sense that it permits possibles to branch towards the future, but also in the sense that it, more radically than standard tense logic, discards the classical idea of a timeless truth implying truth to emerge in time along with the reality it depicts. Truth is nevertheless assumed to be eternal in the sense that, when once established, it can never be annulled or suspended. The system borrows features from Aristotle, Diodoros, Aquinas, Leibniz, Kierkegaard, Peirce, Kripke, and Prior.

$\boldsymbol{K_t}$ and $\boldsymbol{K_b}$ are two very simple tense-logical systems of which soundness and completeness are provable; but, with $\boldsymbol{K_b}$, time acquires a direction so that we can speak of *the arrow of time*, and for this reason alone it is natural to give priority to $\boldsymbol{K_b}$, ahead of $\boldsymbol{K_t}$. $\boldsymbol{K_b}$ is designated by a successive loss of possibility. The actualization of only one among an infinity of possibilities means that most possible futures are successively eliminated. Thus, what was possible in the past may now be excluded. But, making use of Prior's concept of statability, this steady loss of possibility is compensated by a steady increase in the sum of statable truth. For this reason, *the flow of time is mind-independent*.

The sum of statable truth is steadily increasing, due to the fact that assertions that were not hitherto statable are becoming statable in the course of time. Being now statable, we shall assume that they remain forever statable, so that propositions feigning departed individuals to be present are just false. Granted this, we shall claim that what is true now will inevitably have been true. By contrast it is uncertain whether what is now statable was always statable, so we cannot know if what is true now was always going to be true. Hence, our system *$\mathcal{W}$ makes it meaningful to speak of a Creation of Truth*.

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