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# BECOMING AS A BRIDGE BETWEEN QUANTUM MECHANICS AND RELATIVITY

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**Abstract:** Time's apparent "flow" is often dismissed in physical theory. We propose to take it as a real property of reality and show how the addition of this assumption to physics' prevailing postulate yields, a new framework within which relativity and quantum theories are in harmony with one another.

## 1 INTRODUCTION

For more than a century since the advent of relativity theory and quantum mechanics, the two theories have made tremendous progress, yet the conflict between their principles has only become sharper. A more fundamental theory, within which the two theories would naturally fit in as special cases, is not yet at sight.

Unrelated to this stalemate, a much older debate goes on concerning the nature of time. Why does time, unlike space, appear to be "flowing"? And why are certain processes asymmetric in time, in contrast to their spatial symmetry?

We submit that addressing the latter issue may yield a new resolution to the former. In what follows we propose that time's apparent "flow" is real, and then proceed to show how this assumption might enable quantum mechanics and relativity theory to begin merging into a new theory.

This is a highly speculative work. We claim neither rigor nor certainty.

It is after several years of working on specific problems that we feel that time is ripe for a more daring synthesis, even at the cost of being loose.

The structure of our theory is like that of any scientific theory. At the basis we introduce a few known principles of prevailing physical theories as postulates, plus one new assumption. In return we hope to derive *i*) conclusions already accepted as correct although not assumed, and, *ii*) testable predictions. Unfortunately, nothing like *ii*) has been yielded by our theory yet, to say nothing of confirmation, otherwise we would be singing it from all the roofs. Yet, because something like *i*) seems to have emerged from time to time along our search, we dare take it as a hint that we may be on the right track.

## 2 "BLOCK UNIVERSE" OR "PRESENTISM"?

Mainstream physics' account of time is known as the "Block Universe." Rooted in the theory of relativity, it portrays the universe as a four-dimensional continuum in which all past, present and future events have the same degree of existence along time, just as different locations coexist along space. All three-dimensional objects are "slices" of four-dimensional world-lines, extending from past to future. An object's motion is a curvature on its world-line.

The rival model, "Presentism," tries to account for our perception of time by asserting that only present events are real. States merely appear and vanish, consecutively, "time" being just the sum of these changes. Referring to time as a dimension, so goes this view, is only a useful metaphor, and relativistic notions like "spacetime" and "world lines" are mere abstractions. Only the "Now" is real, and is the same everywhere. Of course, in order to avoid conflict with relativity (see [1]), Presentism must concede that this simultaneity can never be observed. This concession is not necessarily a disadvantage of the model, as unobservable elements of nature feature in many respectable theories.

Both models come with a price. The former dismisses our subjective sensation of time, while the latter gives up full conformance with relativity, yet both are self-consistent. It is only when trying to blend the two notions to mach both subjectivity and relativity, that serious paradoxes ensue. For example, taking time to be the fourth dimension *together with* an objective "Now" is bound to imply a yet higher time dimension within which the "Now" is supposed to proceed. Only the two extremes in their pure form seem to be viable, the Block Universe being mainstream physics' choice while Presentism is opted by a minority.

The option we seek is different. We wish to preserve the essential elements of relativity theory, but we also want to take the "Now" as a key to a deeper layer of physical reality. And, of course, we hope to avoid the paradoxes that often follow such a double standard. We name the proposed model the Spacetime Dynamics theory, as it suggests that spacetime itself is subject to evolution.

Let us, then, first point out those essential elements of relativity theory that are likely to remain within any future theory. First is the notion of a four-dimensional spacetime. General relativity's interpretation of gravity as a curvature of spacetime is one of the theory's greatest achievements, well-supported by all experimental tests. Even some yet-unknown aspects of spacetime, such as its form in a black hole singularity or at the Planck scale, give valuable leads for future research. Similarly constructive is the notion of a world-line, portraying any object as a four-dimensional line extending from past to future. The world-line notion provides, *e.g.*, the best understanding of relativistic contraction (see [2]). At the micro level, Feynmann's diagrams, especially the idea of an anti-particle being a particle that moves backwards in time [3], testifies to the great heuristic potential of the 4-D spacetime. Two modern interpretations of QM, namely, Aharonov's [4] and Cramer's [5], elegantly invoke spacetime zigzags in order to account for some of the peculiarities of quantum phenomena (see [6]). All these are promising elements of the relativistic spacetime, which we intend to preserve within the Spacetime Dynamics theory.

It is with respect to two other assertions that the Block Universe model turns out to be very awkward:

1. There is no objective "Now" moving from one minute to another. Each event is "Now" for its observer. Similarly, "past" and "future" are relative terms just as, say, "East" and "West."
2. At any moment, future events are as real as present events and as fixed as past events. It is only because no information comes from the future (due to the second law of thermodynamics, which can be assumed even within the Block Universe framework) that future events seem not to exist.

These assertions have odd consequences. Every person, rather than being just one person undergoing many events, is supposed to be a series of equally-existing momentary persons, each residing in its moment. Every such a momentary self is a 3-D "slice" of the 4-D world-line, which in itself does not move or change. Every momentary self possesses memories of the previous ones, thereby having the illusion that he or she is one and the same person who has been through all past events. Whatever is going to happen in the future, even one's own actions, "already" exists, albeit unknown, together with the future selves, and cannot be changed or avoided, just like past events.[a]

This account is awkward not only in terms of ordinary experience but in the quantum context as well. In earlier publications we have presented three results that, although not disproving the Block Universe, seriously undermine it:

1. *"Hidden variables must be forever-hidden variables"* Consider a photon at time $t$ after being emitted from its source. Its wave function describes its position as a superposition, which will give its place ("collapse") to a definite position only upon measurement. Now quantum theory can only give probabilities for that future position. In order to assume that the future position is pre-determined already at $t$, one has to invoke hidden variables of some sort. However, elsewhere [2] we have given a very straightforward proof for the following. *In any theory within which relativity remains valid, quantum hidden variables must never be observed, since observing them is bound to produce violations of relativistic invariance.* Such invocation of something that must exist but never be observed – properties that even the $19^{th}$-Century ether was not claimed to have – places hidden variables in the realm of religion rather than science.[b] It is, therefore, the combined lesson of both QM and relativity that gives us an important hint: There are future events that can never be predicted by a present state. Would it not be reasonable, then, to doubt whether such future events exist in the first place?

2. *The Indeterminacy-Asymmetry Entailment* If quantum theory indeed reveals a genuinely indeterminate element that takes part in any interaction, then, in any closed system, an arrow of time must eventually emerge, regardless of the system's initial conditions and concurring with the time arrow of the universe outside, from which the system

[a]This account, it should be stressed, is not just one possibole interpretatin of relativity theory but an inevitable part of it. This was Einstein's own view; see [7] for a detailed discussion.
[b]"For there shall no man see me, and live." – Exodus 33: 20.

is supposed to be shielded [8]. Hence, the Block Universe assertion "the future determines the present just like the past," is simply wrong. True, the question of determinism *vs.* indeterminism has not been decisively resolved yet, but given our above proof that "hidden variables must be forever-hidden variables," strong determinism is a metaphysical theory. Consequently, by the Indeterminacy-Asymmetry Entailment, an initial low-entropy state can causally bring about the final high-entropy state but *not vice versa*. This conclusion strongly undermines the Minkowskian picture of future events coexisting in time alongside with the present.

3. *Quantum Mutual measurements Entailing Inconsistent Histories* As odd as the famous quantum effects are known to be, e.g., single-particle interference and the EPR experiment, they yield self-consistent evolutions. We have shown, however, a few cases where even this consistency does not hold [9]. When the quantum measurement is delayed, such that one particle "measures" another particle before the macroscopic device completes the measurement, something intriguing occurs: The outcome is self-contradictory – a quantum version of the Liar Paradox [2]. These results further undermine the notion of a fixed spacetime within which all events maintain simple causal relations. Rather, it seems that quantum measurement can sometimes "rewrite" a process's history.

Something, then, seems to be flawed with the orthodox view of time as a mere dimension. Bearing in mind that the nature of time has an immediate bearing on many physical issues, it is reasonable to expect that a deeper theory of time will shed a new light on some other conundrums in the foundations of physics.

## 3 THE ASSUMPTION: BECOMING IS REAL

The Spacetime Dynamics theory makes one new assumption:

**The Assumption Of Becoming:** What an observer perceives as "Now" is a special moment which marks the genuine creation of new events. World-lines objectively "grow" in the future direction. At any moment in time which an observer perceives as "Now," future events are not only unknown but *objectively inexistent*, to be created later as the "Now" advances.

Notice that the Block Universe is preserved as a special case in this model: Spacetime with its world lines exist in the past, but not in the future. Broad [10] and Sider [11] refers to this as the "Growing Block Universe."

in what follows, the new theory's postulates will be all the prevailing physical principles and effects ,plus this new assumption. Let us follow their consequences.

## 4 MACH'S PRINCIPLE EXTENDED: SPACETIME ITSELF UNFOLDS WITH THE UNFOLDING OF NEW EVENTS

Our first postulate is a simple principle due to Mach [12]:

**Postulate A:** Space and time are inconceivable in the absence of events.

The logical consequence of the Becoming Assumption and Postulate A is that we cannot conceive of new events being added to some empty spacetime in the future. Rather, spacetime itself must be "growing" in the future direction, alongside with the "growth" of the world-lines and the creation of new events. Hence,

**Consequence 1:** Any moment in time which an observer perceives as "Now" is simply the edge of time: *Nothing*, not even spacetime, exists beyond it.

While it is easy to illustrate spacetime with the familiar Minkowski diagram, our alternative model eludes graphic representation. We could draw a Minkowski diagram with an upper boundary representing the "Now", where all world-lines simply end, but that would be misleading: The empty surface above the "Now" would still have the diagram's spatial dimensions. It is simply impossible so portray the absence of space! But it is this very difficulty that should give us an insight into the reason why physical theory has been stagnating so long in this respect. Space, as Kant [13] has proven, underlies any possible though; we cannot think even the most abstract thought without implicitly assuming some underlying space. Bergson [14] has further shown that this problem besets modern physics' theorizing about time: We keep "spatializing" time. One should be aware of this inherent limitation of human thinking when seeking to transcend the present account of space and time.

## 5 COSMOLOGY EXTENDED: SPACETIME EXPANDS IN THE TIME DIRECTION TOO

It cannot escape us that Consequences 1 has a strong affinity to mainstream cosmology's standard model:

**Postulate B:** Spacetime, ever since the Big Bang, keeps expanding.

But then, if the advancing "Now" is the edge of time beyond which no spacetime exists, then spacetime must be expanding in the time direction too. We move away from past events, perhaps, not unlike the way we move away from neighboring galaxies. The analogy is not perfect, nor should one try too hard to make it so,[c] but the idea of an expanding time seems to have a striking accord with the universe's spatial expansion.

**Consequence 2:** The universe's evolution involves the growth of both space and time. Alongside with the expansion of the spatial dimension, time expands too as the advancing "Now" creates more events together with their associated spacetime.

## 6 INFINITY OF TIMES AVOIDED

Cosmology gives us another valuable clue for dealing with an old problem. Most theorists avoided Becoming because it seemed to inevitably entail an endless series of higher and higher time parameters. For if the "Now" moves along time, than time itself constitutes merely a dimension for this movement, and an additional time must be assumed for this motion to occur. Cosmology, however, has dealt with a similar problem. The question "what happened before the Big Bang?" is routinely dismissed as meaningless by pointing out that "before" entails time and time itself was created in the Big Bang. Yet, several models invoked some "pregeometry" which existed "before" the Big Bang.[16] The validity of these speculations does not concern us here, but the basic idea is useful: The primordial geometry does not have to be the same as our present geometry, but of a more primitive kind, characterized by different axioms, and thus no infinite series of geometries is entailed.

Similarly for our case, there is no need to invoke a yet higher dimension

[c]The main difference is that spacetime has no boundaries in the Big Bang theory while the "Now" assumed here constitutes a clear boundary. Still, the Big Bang itself is a boundary in time (Hawking's [15] attempt to eliminate it has not been generally accepted). Black holes constitute boundaries too. Moreover, it is not clear why boundaries should be considered a disadvantage for a theory.

for the development of spacetime, because this development can be of a more primitive kind. Recall that Presentism, the model rivaling the Block Universe, makes a self-consistent assertion: Time is nothing but change, "the fourth dimension" being merely a metaphor. Most physicists dismiss this option, and so do we, as it does not accord with relativity theory. But this reason does not apply for the dynamics of spacetime itself. If spacetime is subject to dynamics, such as growth in the future direction, there is no reason to assume that this dynamics is also subject to the laws of relativity. Velocities may be infinite, absolute simultaneity may hold, and therefore no higher dimension may have to be invoked. Bergson's [14] radical idea about pure change which transcends any dimensionality can therefore be neatly integrated with the relativistic spacetime, simply by assigning the former a more fundamental status:

**Consequence 3:** Change is more fundamental than space and time. Relativistic spacetime is subject to changes, such as the growth of its spatial and temporal dimensions. This is pure change, i.e., one state coming into existence after another, not subject to relativistic constraints, hence possessing no dimensionality whatsoever.

## 7 RELATIVITY DYNAMIZED: INTERACTION PRECEDES SPACETIME

The Big Bang model has asserted what a few philosophers have earlier speculated: Space and time are not primary entities but derivatives of the unique event of creation. Our theory goes one step further to suggest that this creation of spacetime is continuous, thus affirming the naïve impression that every moment is a new creation.

Next, therefore, let us examine the relativistic principles governing spacetime within the new framework. Here, the Becoming Assumption seems to give these principles an appealing twist. Recall that for spacetime to be conceivable, there has to be not only a body, but two bodies at least, for it takes two bodies to distinguish between relative rest and motion [12]. Our next postulate is therefore taken from relativity:

**Postulate C:** There is no absolute motion or rest. All velocities are relative.

In fact, Mach went further to argue that all effects of inertia on a body

– rest, motion and even acceleration – stem from the mere presence of matter in the universe. In other words, any kinematic state is due to some interaction. These arguments fit in naturally within the Spacetime Dynamics theory:

**Consequence 4:** The interaction between bodies precedes the advance of the "Now." First, bodies interact outside spacetime. Then, as the "Now" advances, a new spacetime zone is formed around the events created by this interaction, elongating the interacting bodies' world-lines and determining the spatiotemporal relations between them. Position, momentum and even acceleration are relative because they arise due to interactions prior to the formation of the spacetime within which they occur.

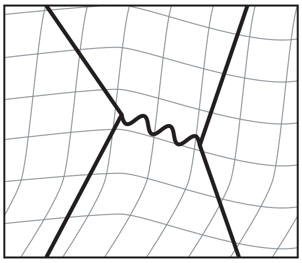

Fig. 1. Block Universe model.

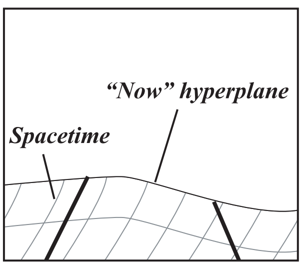


Fig. 2. Initial state.

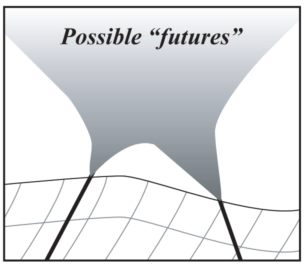


Fig. 3. Interaction precedes spacetime.

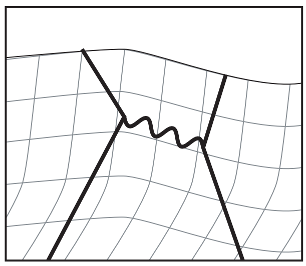

Fig. 4. New spacetime region is created.

Figures 1 and 2-4 portray this hypothesis, contrasting the Spacetime Dynamics theory with the Block Universe. Of course, no serious attempt is made to portray what occurs beyond spacetime or in the presumed pre-spacetime interaction.

Interestingly, the problem of nonlocality that besets Mach's principle is not a hindrance in the present framework. If the initial interactions take place outside spacetime, distances do not matter and the entire matter of the universe can affect any body. Rosen [17] proposed a similar hypothesis.

The relativistic $c$ invariance,

**Postulate D:** The velocity of light is the same in all reference frames.

is amenable to a similar explanation. We recall that $c$ is the velocity of all interactions mediated by zero mass bosons, *e.g.* electromagnetic and gravitational. Here again, the fact that a certain, privileged velocity is rendered by relativity as more basic than space and time, strikingly accords with our assumption that spacetime is not a primary ingredient of physical reality. Rather, perhaps,

**Consequence 5:** The spacetime of every reference frames is *formed* by the gravitational/electromagnetic interaction of that reference frame with its environment. These interactions, which occur in the pre-spacetime stage, determine the spatio-temporal distances between the events, such that the speed of light always appears the same.

We have thus elevated Mach's epistemological principle to an ontological hypothesis: It is not only in our thinking, but in reality, during Becoming, that *interaction precedes space, time, position and momentum.*

## 8 QUANTUM-MECHANICS AND RELATIVITY INTEGRATED: MACROSCOPIC SUPERPOSITION ENABLES THE PRE-SPACETIME INTERACTION

Dynamizing Mach's principle, turning it into a real component of Becoming, offers a deeper explanation not only to the principles of relativity theory but to quantum phenomena as well. "Superposition," the most fundamental ingredient of QM, denotes the coexistence of several mutually exclusive states, such as many positions of the same particle. Ever since the discovery of this state it kept posing two problems:

1. While superposition of microscopic objects has been demonstrated in numerous experiments, no macroscopic objects are observed super-

posed, even though quantum theory obliges the latter case just as well. A single particle can apparently traverse two slits at the same time, but a dead-plus-alive cat is never encountered.

2. Moreover, even the theoretical possibility of macroscopic superposition entails a serious problem within the framework of General Relativity. Suppose that a massive object is superposed. Then, not only its position within space, but the gravitational field associated with it as well, must be superposed. Now since gravitation is defined by GR as a curvature of spacetime, an awkward situation emerges when this curvature is supposed to be superposed. While we can imagine a superposition of something within spacetime, it is hard to figure out within what can spacetime itself be in superposition.

Two major attempts were made so far to deal with this question:

1. The Many-Worlds interpretation asserts that the whole wave function of the Universe splits with every occurrence of superposition. Here too, many spacetimes are implicitly supposed to coexist within some undefined superspace.
2. Penrose's hypothesis [18] suggests that "collapse" occurs once the difference between two superposed states, in terms of spacetime curvature, exceeds that of one graviton.

Hypothesis (2) is bold and ingenious, but there is a more far-reaching possibility. If

**Postulate E:** Macroscopic superposition, though obliged by QM, is never observed,

then, perhaps,

**Consequence 6:** Macroscopic superposition occurs just as the microscopic one, but beyond the advancing "Now," where spacetime does not exist yet. All macroscopic phenomena have been genuinely superposed, but collapsed together with the progression of the "Now." Superposition does not evolve in empty spacetime. Rather, it marks the absence of spacetime in the future.

An interesting affinity now emerges, which perhaps is not coincidental: Many quantum physicists try to avoid the notion of "collapse," preferring hidden-variable interpretations of QM, because of the non-relativistic implications of this collapse and its time-asymmetry. The advancing "Now," of course, is also generally dismissed, for reasons discussed above. Yet collapse remains the simplest explanation for the difference between micro- and macroscopic phenomena, and the "Now" keeps being the most immediate feature of our experience. Perhaps, then, these two enigmatic phenomena are one and the same?

**Consequence 7:** "Collapse" marks the very advance of the "Now," by which several potential future outcomes of a certain state give place to one definite outcome in the present.

Once the more difficult phenomenon of macroscopic superposition has been addressed, the "ordinary" superposition, occurring at the microscopic scale, becomes much more natural. We know that

**Postulate F:** Most physical characteristics of macroscopic reality hold, at the microscopic scale, only statistically,

and

**Postulate G:** Many quantum oddities (e.g., the EPR and the delayed-choice experiments) can be interpreted as stemming from retroactive effects of the measurement backwards in time.

which pose the following restriction on Becoming:

**Consequence 8:** While the "Now" generally advances forward in time, at the quantum scale it might move also backwards. Limited spacetime segments, such as the superposed trajectories of a particle, are sometimes left "void" by the general Becoming, to be retroactively filled later by future interactions.

Our hypothesis is that microscopic superposition differs from the macroscopic one in that the former occurs within a spacetime already formed by the surrounding macroscopic bodies, previously collapsed with the advancing "Now" and leaving only a few causal chains incomplete. Measurement, that is, the interaction of the particle's wave function with other (unsuperposed) objects, fills these chains backwards. The famous time-symmetry of quantum interactions [19] may indicate that quantum evolution sometimes proceed forward in the time of Becoming but backwards in the relativistic $t$. In other words, while the "Now" generally advanced forward, it may sometimes "go back" in the $-t$ direction to fill some paths which have remained void.

Our hypothesis of a pre-spacetime stage preceding the formation of every instant is a dynamic version of Rosen's [17] notion of a deeper level of reality which is "fundamentally and predominantly nonspatial and nontemporal in character."

## 9 TIME'S ARROW ANCHORED: THE ADVANCING "NOW" IS THE MASTER ASYMMETRY

Penrose [20], in a very bold move, conjectured that once a theory of quantum gravity is available, one cherished ideal of physics will be sacrificed, namely, time asymmetry. In other words, a tiny time-asymmetry may hide in the basic physical interactions. Although Penrose occasionally endorsed the Block Universe, his heresy accords much better with the notion of Becoming. The advancing "Now" is supposed, by definition, to move forward, hence is the best candidate to be the long sought-for "master asymmetry" from which all other time asymmetries (entropy, black hole formation, K-mesons T-violation, etc.) stem. Moreover, if future events genuinely do not exist at any "Now," quantum indeterminacy is also genuine rather than reflecting some unobservable hidden variables. Then, by the Indeterminacy-Asymmetry Entailment [8], entropy increase naturally follows.

**Consequence 9:** The advancing "Now" is the source of all time-asymmetries. Entropy increases already when different wave functions interact in advance of the "Now." The consequent formation of spacetime makes these interactions irreversible.

In this respect, at least, the Spacetime Dynamics theory has an undeniable advantage over the Block Universe. In the latter, time arrows like the thermodynamic entropy increase are merely assumed, as additions to the four-dimensional spacetime. They are obliged by everyday experience but with no justification in the theory itself (see [21]). In the Spacetime Dynamics theory, in contrast, indeterminism and entropy increase are necessary consequences of spacetime's nature.

## 10 CLUES FOR FIELD THEORY: COLLAPSE OF MACROSCOPIC SUPERPOSITION AS THE SOURCE OF ATTRACTION/REPULSION BETWEEN BODIES

Let us reiterate our last steps. We speculated that relative positions and momenta of bodies, with all the resulting relativistic effects, are due to pre-spacetime interactions, after which, with the advance of the "Now," spacetime forms around the new events (Consequence 4). Then, in the context of quantum mechanics, we speculated that macroscopic superpositions also occur outside of spacetime, beyond the "Now" (Consequence 6). As Consequences 4 and 6 propose essentially the same thing, we may venture to conclude:

**Consequence 10:** The wave function of a macroscopic body creates a genuine superposition in the pre-spacetime state beyond the "Now." Several such wave functions, when interacting outside spacetime, exert "measurements" on one another, leading to mutual collapse and to relative positions and momenta. Relativistic effects are due to these mutual quantum measurements of macroscopic bodies during the pre-spacetime stage.

Next, another pair of postulates, one from QM and one from relativity, may integrate into a new consequence of the Spacetime Dynamics theory:

**Postulate H:** When a particles' position is measured and the particle is found not to reside at that point in space, the entire wave function is affected by this negative measurement and the likelihood for collapse increases elsewhere.

This is the familiar result known as "interaction-free measurement" [22]. It oddly renders the position of a particle a result of its being measured elsewhere and *not found* there. Apparently, this quantum mechanical peculiarity has nothing to do with the general relativistic principle

**Postulate I:** Spacetime is curved in the vicinity of mass.

But both phenomena might be unified by a single new definition of macroscopic collapse within the framework of the Spacetime Dynamics theory:

**Consequence 11:** When a macroscopic body is superposed at the pre-spacetime stage, its "collapse" gives rise not only to its position or momentum at some definite site and time. It also gives rise to all the empty sites in spacetime where the body *could* have been located.

Again, "position" gains an entirely new meaning by this formulation. Rather than a body being located in some empty space, both the body and its associated spacetime are created by the same wave function. But now, *changes* in relative positions, namely, *accelerations*, call for a new formulation:

**Consequence 12:** Attraction between bodies results from the special configuration of spacetime around the interacting bodies. There is, so to speak, "less space" between attracting bodies.

Having suggested that, it occurs to us that not only attraction but repulsion too can be given a new understanding in such a framework. Repulsion, however, occurs only in electromagnetism and not in gravity, and the long sought-for unification of the two realms is still far away. But perhaps the new reformulation, namely attraction/repulsion being due to special spacetime regions created by the wave functions around the interacting bodies, can give a hint towards this goal.

## 11 SUMMARY AND APOLOGY

The omnivorous synthesis we proposed here originates from a twofold motivation. First, we find the Block Universe extremely odd. Second, many unresolved riddles in physics are obviously related to the nature of time, indicating that something essential is still missing in the relativistic account. Especially QM seems to keep telling us that the idea of a fixed, objectively existing future is obscure metaphysics. We therefore suggested adding Becoming to the existing postulates of theoretical physics.

Trying to preserve the essential features of both relativistic time and the idea of Becoming, we integrated them in a picture which ascribed pure change, without dimensionality, to spacetime itself, while relativity theory holds within that spacetime, thus becoming a special case of the Spacetime Dynamics theory. Applying Mach's principles, we concluded that Becoming involves not only the growth of world-lines but also the growth of spacetime itself in the future direction, in perhaps nontrivial resemblance with spacetime's spatial expansion in the Big Bang model. In other words, whereas present-day cosmology invokes one unique event of the creation of spacetime from nothing, we propose that at every instant, a new segment of spacetime is created, added to the universe's history.

Then, following Mach's principles and the principles of special relativity, we gave precedence to events over space and time, and precedence to relations over events. Consequently, we proposed that relative positions and momenta are formed in the pre-spacetime stage of every instant, ahead of the advancing "Now." Next, from the viewpoint of QM, addressing the apparent absence of macroscopic superpositions, we proposed that such states also exist in the pre-spacetime stage. Our next speculation, then, proposed a unification: It is the wave-functions of macroscopic objects that interact with one another beyond the "Now," so as to establish relative positions and momenta. Spacetime, according to this speculation, is formed only after the interactions. Applying Machian thinking even further, we suggested that the collapsing wave functions, upon measuring one another, create both the bodies and their associated spacetime. Thus, "position" and "momentum" gained an entirely new meaning. But then, perhaps even the phenomena of attraction and repulsion can get a new twist in this paradigm, by assuming that bodies created different configurations of spacetime between them so as to become closer or farther. From another perspective, that of thermodynamics, time's asymmetry, rather than being a fact-like feature of physical reality added "by hand" to the physical account of spacetime, became, together with indeterminism, part and parcel of it.

We anticipate the objections by which the Spacetime Dynamics theory may be dismissed, as we are painfully aware of them ourselves. At this stage the theory is vague, relying too much on intuitive guesses, lacking formal rigor and offering no testable predictions. If we venture to propose it nonetheless, it is in protest against the dearth of theorizing in current theoretical physics, dearth which we find, particularly in this centenary of the Annus Mirabilis, unacceptable. Physicists rarely dare to propose unconventional ideas nowadays, despite growing discontent with the prevailing models of spacetime, quantum, and the universe. It is time to move on. New hypotheses, even highly tentative, provide the best impetus for such a move.

Particularly odd in this respect is the impoverishment of the superstring models. While they reasonably seek to revise the account of spacetime for a better understanding of matter and energy, they rarely bother to address the "old" riddles of QM such as wave-particle duality, non-locality and macroscopic superposition. It is highly unlikely that a theory that ignores these riddles will ever come up with the long waited-for unification of relativity and quantum theories.

Even odder is superstring theories' muteness about the nature of time. In marked contrast with their lavishness concerning space – adding many hidden spatial dimensions – they leave time, with all its enigmatic features such as transience and asymmetry, as ill-understood as ever. We, in contras, believe that even in the above sketchy account we were able to point out the enormous theoretical potential of the Becoming Assumption, as it so naturally provides a hidden time within which possible interactions can operate on the Minkowski-Einstein spacetime.

Cosmology, on the other hand, has been bolder, exploring many exotic features of the physical reality that might have existed prior to the Big Bang. "Pre-geometries," possessing primitive features that might lie beneath our familiar geometry, are being studied, and here superstring theories do yield important insights. Our modest contribution in this respect is the proposition that *the Big Bang is incessant.* Every new instant is a genuine creation *ex nihilo* of another segment of spacetime together with its events, just as the Big Bang is supposed to have been at the beginning of the universe. Let, then, all the speculations about the conditions that preceded the Big Bang be applied the unfolding of the next moment. Profound insights might emerge from such an attempt.

It is to the future, which we believe to be really undetermined, that we relegate the final judgment on this proposal.

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